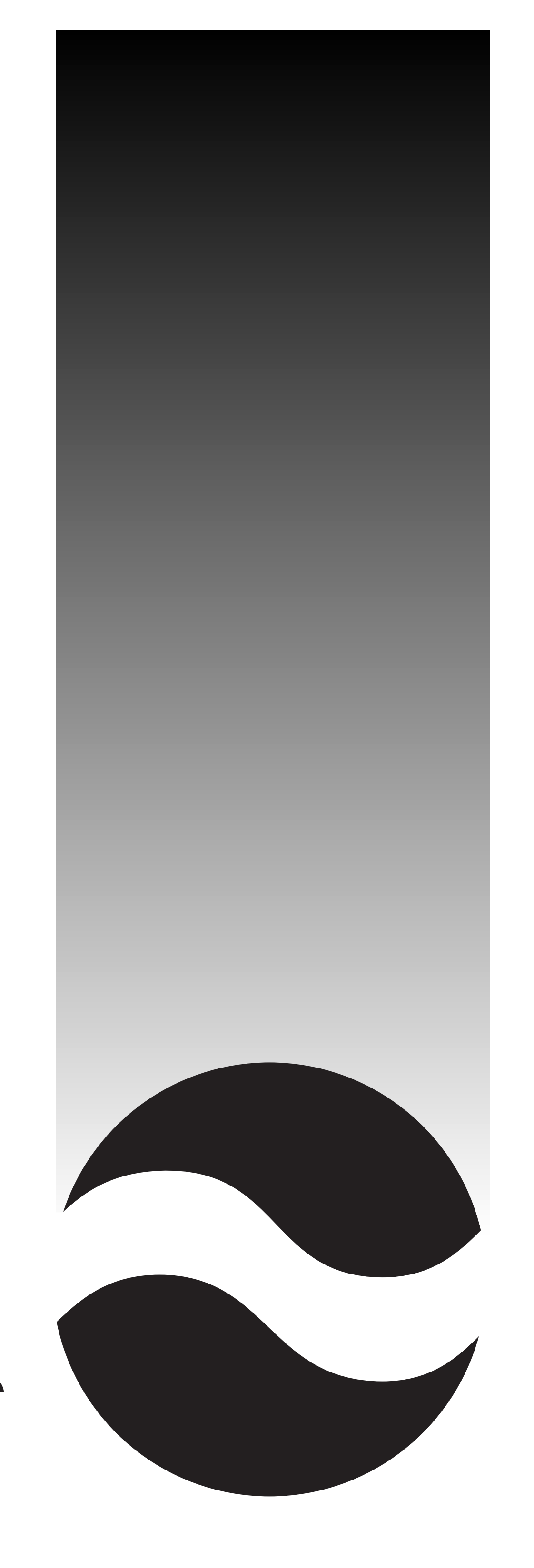
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October 1998



JOINT INDUSTRY STANDARD

Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires



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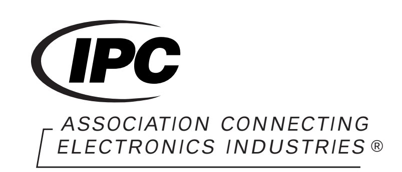
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For Technical Information Contact:

EIA/ECA/JEDEC
2500 Wilson Boulevard
Arlington, VA 22201
Phone (703) 907-7500
Fax (703) 907-7501

IPC
2215 Sanders Road
Northbrook, IL 60062-6135
Phone (847) 509-9700
Fax (847) 509-9798

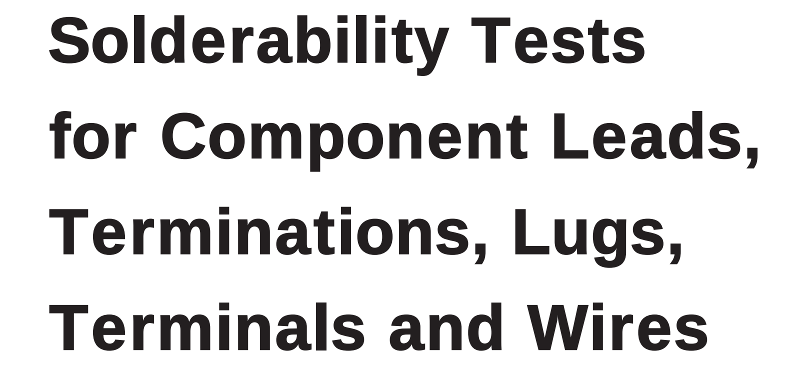
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IPC/EIA/JEDEC J-STD-002B



Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

A joint standard developed by the ECA Soldering Technology Committee (STC), the Component and Wire Solderability Specification Task Group of IPC, the JEDEC JC-13 TG9901 Solderability Test Method Task Group and JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices



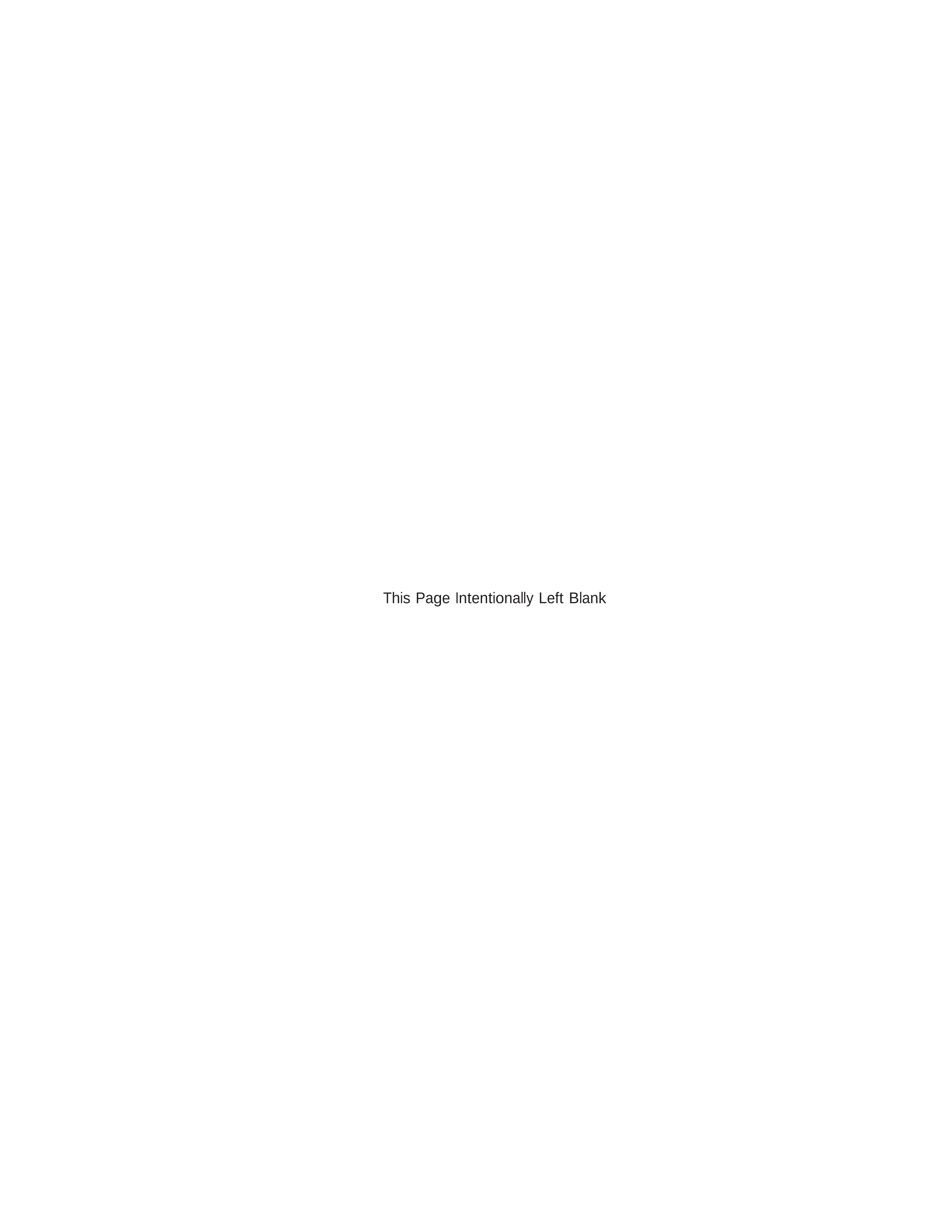
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Contact:

EIA/ECA/JEDEC
2500 Wilson Boulevard
Arlington, VA 22201
Phone (703) 907-7500
Fax (703) 907-7501

IPC
2215 Sanders Road
Northbrook, IL 60062-6135
Phone (847) 509-9700
Fax (847) 509-9798


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Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the Solderability Specifications Working Group are shown below, it is not possible to include all of those who assisted in the evolution of this Standard. To each of them, the members of the IPC and the EIA associations ECA and JEDEC extend their gratitude.

IPC Assembly & Joining Processes Committee

Chair
James F. Maguire
Intel Corporation

Component & Wire Solderability Specification Task Group

Chair
David Hillman
Rockwell Collins

ECA Soldering Technology Committee

Chair
Douglas Romm
Texas Instruments, Incorporated

JEDEC JC-13 TG9901 Committee

Chair
Mark Kwoka
Intersil Corporation

JEDEC JC-14.1 Committee

Chair
Jack McCullen
Intel Corporation

Component & Wire Solderability Specification Working Group

Donald Abbott, Ph.D., Texas Instruments Inc.
Annalie Acosta, Tundra Semiconductor
David C. Adams, Rockwell Collins
Tim Adams, Silicon Storage Technology
Diek Albertus, Albertus Electronics
Michael Aldrich, Analog Devices Inc.
Rong An, Huawei Technologies Company
Ali Asiaban, Allegro MicroSystems
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Francis Anglade, Metronelec
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Steve Brockett, Triquint Semiconductor
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Sidney Cheng, OMG Americas
Sunil K. Chhabra, SUNY (State Univ. of New York)
Beverley Christian, Ph.D., Research In Motion Limited
Elaine Colokathis, Alternate Final Finishes, Inc.
David J. Corbett, Defense Supply Center Columbus
Kendall Cottengim, DSCC-VAT
Harlan Cramer, Northrop Grumman
Donald P. Cullen, MacDermid, Inc.
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Yeng Peng, Taiwan Semiconductor Mfg
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John W. Porter, Loctite Multicore Electronics
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Tapan Pramanik, National Semiconductor
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Douglas Romm, Texas Instruments Inc.
Michael M. Rubin, Vishay Sprague Sanford
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Rudy Sedlak, RD Chemical Co.
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John E. Sohn Ph.D.

John Solomon, Multisorb Technologies

David Sorrells, Compaq Computer

Harry Spence, Microsemi

Frank Stein, Ph.D.

Mark Stibite, F15 Engineering

Simon Su, Advanced Semiconductor Engineering

Craig Taylor, Actel

Karen A. Tellefsen, Ph.D., Alpha Metals

Morgan Tench, Ph.D., Rockwell Science Center

Tracy Tennant, Micron Technology

Ed R. Tidwell, Alcatel USA

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Stephen Todd, FCI Electronics

Jerome Tofel, Northrop Grumman Corporation

Brian J. Toleno, Ph.D., Loctite Corporation

W. Lee Vroom, Thomson Consumer Electronics

Michael Ward, Omnirel

Karl F. Wengenroth, Enthone Inc.

George M. Wenger, Celiant Corporation

Keith J. Whitlaw, Shipley Europe Ltd.

Maureen Williams, NIST

David Williamson, High Connection Density

Greg Wood, EMPF/ACI

Thomas A. Woodrow, Ph.D., Boeing Phantom Works

John Young, Aeroflex

Shaw Yin, GSI Technology

Michael W. Yuen, Hewlett-Packard Company

Adam R. Zbrzezny, Celestica International Inc.

Xin Zhao, Cirrus Logic

Wen Zheng, Cypress Semiconductor

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Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

1 SCOPE

1.1 Scope This standard prescribes test methods, defect definitions, acceptance criteria, and illustrations for assessing the solderability of electronic component leads, terminations, solid wire, stranded wire, lugs, and tabs. This standard is intended for use by both vendor and user.

1.2 Purpose Solderability evaluations are made to verify that the solderability of component leads and terminations meets the requirements established in this standard and that subsequent storage has had no adverse effect on the ability to solder components to an interconnecting substrate. Determination of solderability can be made at the time of manufacture, at receipt of the components by the user, or just before assembly and soldering.

The resistance to dissolution of metallization determination is made to verify that metallized terminations will remain intact throughout the assembly soldering processes.

1.3 Method Classification This standard describes methods by which component leads or terminations may be evaluated for solderability. Test A, Test B, or Test C and Test D, unless otherwise agreed upon between vendor and user, are to be used for each application as a default.

1.3.1 Tests with Established Accept/Reject Criteria

Test A – Solder Bath/Dip and Look Test (Leaded Components and Stranded Wire)
Test B – Solder Bath/Dip and Look Test (Leadless Components)
Test C – Wrapped Wire Test (Lugs, Tabs, Hooked Leads, and Turrets)
Test D – Resistance to Dissolution/Dewetting of Metallization Test
Test S – Surface Mount Process Simulation Test

1.3.2 Test without Established Accept/Reject Criteria

Test E – Wetting Balance Test (Leaded Components)
Test F – Wetting Balance Test (Leadless Components)

These methods are included for evaluation purposes only. Data collected should be submitted to the IPC Wetting Balance Task Group for correlation and analysis.

1.4 Coating Durability The following are guidelines for determining the needed level of steam conditioning category assurance (see Table 1-1). The user and vendor need to agree on the coating durability requirements. If this is not provided, Coating Durability Category 3 becomes the default condition for tin and tin/lead finishes.

Category 1 — Minimum Coating Durability Intended for surfaces that will be soldered within a short period of time (e.g., up to six months) from the time of testing and are likely to experience a minimum of thermal exposures before soldering (see 5.8).

Category 2 — Typical Coating Durability (for nontin and nontin-lead finishes) Intended for surfaces finished with other than Sn or Sn/Pb coatings that will be soldered after an extended time from the time of testing and which may see limited thermal exposures before soldering (see 5.8).

Category 3 – Typical Coating Durability (default for tin and tin-lead finishes) Intended for surfaces finished with Sn or Sn/Pb coatings that will be soldered after an extended storage (e.g., greater than four months) from the time of testing and/or which see multiple thermal exposures before soldering (see 5.8).

Table 1-1 Steam Conditioning Categories for Component Leads and Terminations

Category 1	Category 2	Category 3
No Steam Conditioning Requirements	1 Hour ± 5 min. Steam Conditioning	8 hours ± 15 min. Steam Conditioning

1.5 Referee Verification Solder Dip for Tests A, B, C When the dipped portion of the termination exhibits anomalies such as surface roughness, or dross, or anomalies that may have been induced by improper solder dipping, a referee verification solder dip of the suspect anomaly may be necessary. Upon reinspection if the suspect anomaly has been removed, the anomaly will have been verified as a nonrejectable cosmetic surface defect. If the anomaly persists, regardless of area, it **shall** be classified a rejectable solderability defect. This procedure may only be used on one component per lot. Continuous need of procedure is an indication of either improper testing procedure, examination interpretation, or of poor component quality.

1.6 Limitation This standard **shall** not be construed as a production procedure for the pretinning of leads and terminations.

1.7 Contractual Agreement In cases where the stated test parameters are inappropriate or insufficient, alternative parameters may be agreed upon between vendor and user.

2 APPLICABLE DOCUMENTS

The following documents of the issue currently in effect form a part of this standard to the extent specified herein.

2.1 Industry

2.1.1 IPC[1]

IPC-T-50 Terms and Definitions

IPC-CS-70 Guidelines for Chemical Handling Safety in Printed Board Manufacturing

IPC-TR-464 Accelerated Aging for Solderability Evaluations and Addendum

J-STD-004 Requirements For Soldering Fluxes

J-STD-005 Requirements for Soldering Pastes

J-STD-006 Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solder for Electronic Soldering Applications

2.2 Government

2.2.2 Federal[2]

(CID) A-A-59551 Wire, Electrical, Copper (Uninsulated)

3 REQUIREMENTS

3.1 Terms and Definitions The definition of terms **shall** be in accordance with IPC-T-50. Terms that have been repeated from IPC-T-50 for convenience are indicated by an asterisk (*).

*Dewetting** A condition that results when molten solder coats a surface and then recedes to leave irregularly-shaped mounds of solder that are separated by areas that are covered with a thin film of solder and with the basis metal not exposed.

Dissolution Of Termination Metallization (Leaching) Area on the component termination where metallization is lost/removed from the basis/substrate material after immersion in molten solder.

Equilibrium Wetting The degree of wetting in which the forces of wetting are in equilibrium with the forces of gravity. The visible indication of this is when the wetting balance curve flattens out and approaches zero slope (see Figure 4-7).

*Nonwetting, Solder** The partial adherence of molten solder to a surface that it has contacted; basis metal remains exposed.

*Pinhole** An imperfection in the form of a small hole that penetrates entirely through a layer of material.

*Solderability** The ability of a metal to be wetted by molten solder.

*Solder Connection Pinhole** A small hole that penetrates from the surface of a solder connection to a void of indeterminate size within the solder connection.

*Wetting, Solder** The formation of a relatively uniform, smooth, unbroken, and adherent film of solder to a basis metal.

3.2 Materials All chemicals **shall** be of commercial grade or better. Fresh solvents **shall** be used as often as is necessary to preclude contamination.

3.2.1 Solder Solder composition **shall** be Sn60/Pb40 or Sn63/Pb37 per J-STD-006. The composition of the solder, including contamination levels, **shall** be maintained during testing per 3.5.2.

The composition of the solder paste to be used in Test S **shall** be Sn60/Pb40 or Sn63/Pb37 per J-STD-005, mesh size of -325/+500, flux type ROL1 (formerly designated RMA). The solder paste **shall** meet the storage and shelf life requirements of the manufacturers' specification.

3.2.2 Flux The flux for all solderability tests **shall** be a standard activated rosin flux (Type ROL1 per J-STD-004) having a composition of 25% ± 0.5% by weight of colophony and 0.15% ± 0.01% by weight diethylammonium Hydrochloride (CAS 660-68-4), in 74.85% ± 0.5% by weight of isopropyl alcohol. The specific gravity of the standard activated rosin flux **shall** be 0.843 ± 0.005 at 25 ± 2°C [77 ± 3.6°F].

The flux to be used in preparing the standard wire for test C **shall** conform to J-STD-004, Type ROL1. This flux **shall** not be used in performing the solderability tests for any of the methods herein.

3.2.2.1 Flux Maintenance The flux **shall** be covered when not in use and discarded after eight hours or the flux **shall** be maintained to a specific gravity of between 0.842 and 0.846 at 25 ± 2°C [77 ± 3.6°F] and discarded after one week of use.

3.2.3 Flux Removal Material used for cleaning flux from leads and terminations before solderability evaluations **shall** be capable of removing visible flux residues (see 5.5). The cleaned surface **shall** exhibit no mechanical damage.

3.2.4 Standard Copper Wrapping Wire The standard wrapping wire specified in 4.2.3.2.1 **shall** be fabricated

1. www.ipc.org
2. http://astimage.daps.dla.mil/quicksearch/

from type S, soft or drawn and annealed, uncoated in accordance with (CID) A-A-59551.

The nominal diameter of the wrapping wire **shall** be 0.6 mm [0.023 in]. The preparation of the wrapping wire **shall** be as follows:

a. Straighten and cut wire into convenient lengths (50 mm [1.9 in] minimum).

b. Degrease by immersion in an appropriate cleaner (e.g., isopropyl alcohol) for two minutes.

c. Clean in fluoroboric acid 10% HBF (by volume), in water, for five minutes at room temperature with agitation. Use caution in handling.

d. Rinse acid off as follows:
   1. Two nonheated water rinses (deionized or distilled).
   2. Two isopropyl alcohol rinses.
   3. Air dry.

e. Immerse in flux J-STD-004, Type ROL1.

f. Dip in molten solder for five seconds at 245 ± 5°C [473 ± 9°F].

3.2.4.1 To remove or dissolve the residual flux, wash or rinse per 3.2.3.

3.2.4.2 Standard wrapping wire will be stored in a clean, covered container if not used immediately. The usable life of the standard wrapping wire **shall** not exceed 30 days after coating.

3.2.5 The water to be used for steam conditioning purposes **shall** be distilled or deionized.

3.3 Equipment The following equipment applies to more than one of the solderability test methods shown in this standard. Equipment that is specific to any of the test methods is described in the specific Clause 4 paragraphs detailing the method.

3.3.1 Steam Conditioning Apparatus The steam conditioning chamber **shall** be constructed of noncorrodible materials such as borosilicate glass, quartz glass, stainless steel or ptfe. The specimen holder **shall** be nonreactive to prevent galvanic corrosion. The container should be insulated. The steam temperature at the conditioning level **shall** be maintained per the requirements of Table 3-1.

A safe means to prevent excessive pressure and a means of maintaining adequate water level **shall** be provided. Neither **shall** cause the vapor to cool below the specified temperature. Condensate **shall** drip freely back to the water. Care should be taken to minimize contact between the condensate and the specimens.

3.3.2 Solder Vessel A thermostatically controlled static solder vessel **shall** be used for all applicable tests. The solder vessel **shall** be of adequate dimensions to accommodate the specimens and contain sufficient solder to maintain the solder temperature during testing, and to prevent exceeding the contamination levels (see 3.5.1 and 3.5.2). A minimum of 750 grams of solder should be used.

Table 3-1 Steam Temperature Requirements

Altitude	Average Local Boiling Point °C	Steam Temperature Limits °C
0-305 m	100	93 ± 3
305-610 m	99	92 ± 3
610-914 m	98	91 ± 3
914-1219 m	97	90 ± 3
1219-1524 m	96	89 ± 3
1524-1829 m	95	88 ± 3

3.3.3 Optical Inspection Equipment All test methods requiring visual inspection **shall** use microscope(s) capable of magnification 10X (see individual test methods), equipped with reticles, or equivalent, for measurement. An example of a reticle is shown in Figure 3-1. Shadowless lighting **shall** be suitable for proper inspection.

3.3.4 Dipping Equipment Solder dipping devices **shall** be mechanical/electro-mechanical and capable of controlling the immersion/emersion rates, dwell time and immersion depth as specified in 4.2.1 to 4.3.3. Sample holding fixtures **shall** be designed to avoid trapping any excess flux in the fixture and to minimize heat loss and assure reproducibility of test results.

3.3.5 Timing Equipment Timing equipment **shall** be automated, where applicable, and accurate to the limits of the test method.

3.4 Preparation for Testing

3.4.1 Specimen Preparation and Surface Condition All component leads or terminations **shall** be tested in the condition that they would normally be in at the time of assembly soldering. The specimen surfaces to be tested **shall** be handled in such a manner as to not cause contamination, nor **shall** the leads or terminations being tested be wiped, cleaned, scraped or abraded.

Special preparation of leads or terminations, such as bending or reorientation before test, **shall** be specified in the applicable procurement document. If the insulation on stranded wires must be removed, it **shall** be done in a manner so as not to loosen or damage the individual strands of the wire.

3.4.1.1 Steam Conditioning Categories The user **shall** specify to the vendor, as part of the purchase agreement, the required coating durability (see 1.4). Accelerated steam

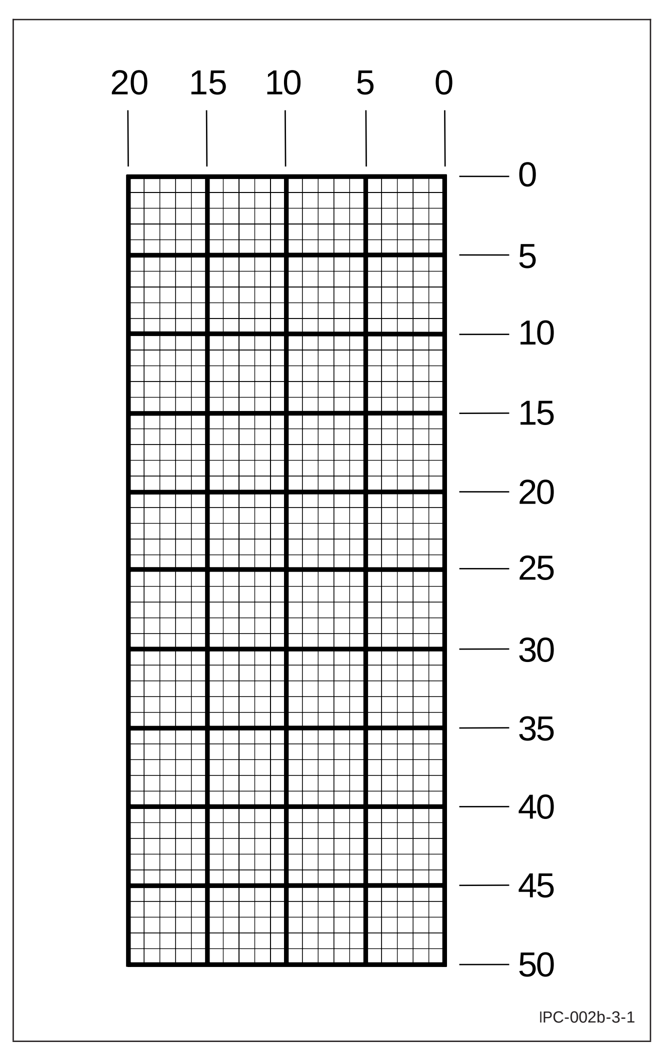


Figure 3-1 Example Reticle

conditioning **shall** be performed per Table 1-1. Solderability testing **shall** be performed per Table 3-2.

3.4.2 Steam Conditioning Before the application of flux and subsequent solderability testing, all specimens to be tested **shall** be conditioned in the device and under the conditions described in 3.3.1 at a steam temperature which is 7°C [12.6°F] below the local boiling point (see Table 3-1).

All components to be tested **shall** be placed into the steam conditioning chamber such that no specimens have their leads or terminations touching and that condensation forming will drain away from the lead or terminations to the package body, i.e., ‘‘Dead Bug’’ for dual-inline packages.

Specimens **shall not** be stacked in a manner which restricts their surface exposure to steam nor **shall** they be placed closer than 10 mm [0.39 in] from the outer chamber walls, and **shall not** touch the inner container walls. In addition, no portion of the specimen **shall** be less than 40 mm [1.57 in] above the water level.

3.4.2.1 Post Age Dry After steam conditioning is complete, specimens **shall** be immediately removed from the chamber and ambient air dried. Solderability testing **shall** be performed within 72 hours of removal from the chamber.

3.4.2.2 Equipment Maintenance Before use, the steam conditioning apparatus **shall** have been cleaned with deionized or distilled water or hydrogen peroxide to remove any accumulated residues. This cleaning should be accomplished within five working days of the conditioning period.

3.4.3 Surfaces to be Tested The critical areas of leads or terminations intended to be soldered **shall** be evaluated for solderability per the test method (see appendix A). This **shall** include both the bottom termination and castellation on chip carriers and on all surfaces intended to be soldered on discrete devices. Through-hole leads that are tested by Method A **shall** have a 25 mm [0.98 in] portion, or the whole lead if less than 25 mm [0.98 in], evaluated for solderability (see 4.2.1.3.2). Test methods **shall** be selected per Table 3-2.

Surfaces to be tested by Method D **shall** be completely immersed in molten solder during dipping (see 4.2.4).

3.5 Solder Bath Requirements

3.5.1 Solder Temperatures Solderability testing **shall** be done at a solder temperature of 245 ± 5°C [473 ± 9°F]. A temperature of 260 ± 5°C [500 ± 9°F] **shall** be used for Test Method D.

3.5.2 Solder Contamination Control The solder in solder baths used for solderability testing **shall** be chemically or spectrographically analyzed or replaced each 30 operating days. The levels of contamination and Sn content must be within those shown in Table 3-3. The intervals between analysis may be lengthened if the test results indicate that the contamination limits are not being approached.

NOTE: An operating day consists of any eight-hour period, or any portion thereof, during which the solder is liquefied and used.

If contamination exceeds the limits specified in Table 3-3, then the solder **shall** be changed and the intervals between analysis **shall** be shortened. A sampling plan **shall** be developed, implemented, and documented, demonstrating solder contamination limit process control.

4 TEST PROCEDURES

4.1 Application of Flux Flux per 3.2.2 **shall** be used. Leads and terminations **shall** have flux applied uniformly, necessary to cover the surfaces to be tested. The flux **shall** be at room temperature.

Table 3-2 Solderability Test Selection Component Type

Test Method	Wrapped Wire	Through-Hole Mount	Surface Mount		
			Leadless	J-Lead	Gull Wing
Tests with Established Accept/Reject Criteria					
A – Dip & Look Test (Leaded Components)		X		X	X
B – Dip & Look Test (Leadless Components)			X		
C – Wrapped Wire Test	X				
D – Resistance to Dissolution of Metallization Test			X	X	X
S – Surface Mount Process Simulation Test			X	X	X
Tests without Established Accept/Reject Criteria					
E – Wetting Balance Test (Leaded Components		X		X	X
F – Wetting Balance Test (Leadless Components)			X		

Table 3-3 Maximum Limits of Solder Bath Contaminant

Contaminant	Maximum Contaminant Weight Percentage Limit
Copper	0.300
Gold	0.200
Cadmium	0.005
Zinc	0.005
Aluminum	0.006
Antimony	0.500
Iron	0.020
Arsenic	0.030
Bismuth	0.250
Silver	0.100
Nickel	0.010

Notes:
1. The tin content of the solder **shall** be maintained within ± 1% of the nominal alloy being used. Tin content **shall** be tested at the same frequency as testing for copper/gold contamination. The balance of the bath **shall** be lead and/or the items listed above.
2. The total of copper, gold, cadmium, zinc, and aluminum contaminants **shall** not exceed 0.4%.

Axial, radial, and multiple leaded components intended for through-hole mounting **shall** have their leads immersed into the flux approximately perpendicular to the flux surface. Leaded or leadless components intended for surface mounting **shall** have their leads or terminations immersed at an angle between 20° and 45° to the flux surface.

The surfaces to be tested **shall** be immersed in the flux for 5 to 10 seconds. Any droplets of flux that may form **shall** be removed by blotting, taking care not to remove the flux coating from the surfaces to be tested. For small passive surface mount devices, the flux droplets may be (but are not required to be) blotted from the surface. The specimens being tested **shall** be allowed to dry for 5 to 20 seconds before solder immersion, but **shall** not be allowed to dwell above solder-pot (no preheat) before actual dipping action.

4.2 Tests with Established Accept/Reject Criteria

4.2.1 Test A – Solder Bath/Dip and Look Test (Leads, Wires, etc.) This test is for solder bath/dip and look testing of leaded components, solid wire, and stranded wire greater than 0.254 mm [0.01 in] minimum.

4.2.1.1 Apparatus

4.2.1.1.1 Solder Pot/Bath A solder vessel that meets the requirements of 3.3.2 **shall** be used. The solder **shall** meet the requirements of 3.2.1. Solder bath temperatures and solder contamination control **shall** be in accordance with 3.5.1 and 3.5.2.

4.2.1.1.2 Dipping Device A mechanical or electromechanical dipping device similar to the device shown in Figure 4-1 **shall** be used unless otherwise agreed to between user and vendor. The rate of immersion, dwell time, and rate of withdrawal **shall** be within the test limits defined in 4.2.1.3. Perpendicularity of through-hole component leads to solder surface **shall** be maintained. Leaded surface mount components **shall** be immersed at between 20° and 45° (or 90° if agreed upon) to the solder surface (see Figure 4-2). This angle **shall** remain consistent for any given component type. Wobble, vibration and other extraneous movements **shall** be minimized.

4.2.1.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

4.2.1.3 Procedure

a. Dross and burned flux **shall** be skimmed from the surface of the molten solder immediately before dipping.
b. The fluxed specimen **shall** be immersed in the molten solder to within 1.25 mm [0.049 in] of the component body or to the seating plane (whichever is further from the component body) for through-hole leaded components (see Figure 4-3).
c. Immerse and withdraw at 25 ± 6 mm [0.984 ± 0.24 in] per second and dwell for 5 +0/-0.5 seconds (see 5.3).
d. After withdrawal, the solder **shall** be allowed to solidify by air cooling while the specimen is maintained in the test attitude.

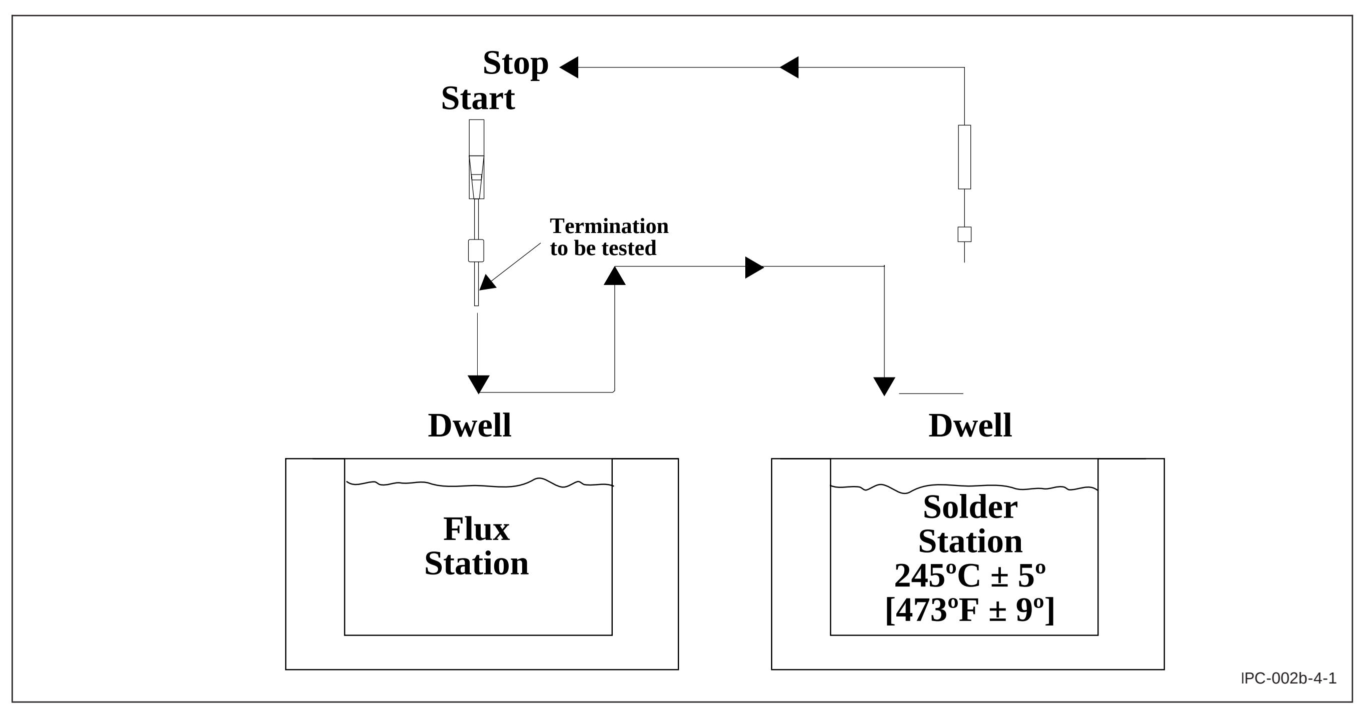


Figure 4-1 Dipping Schematic

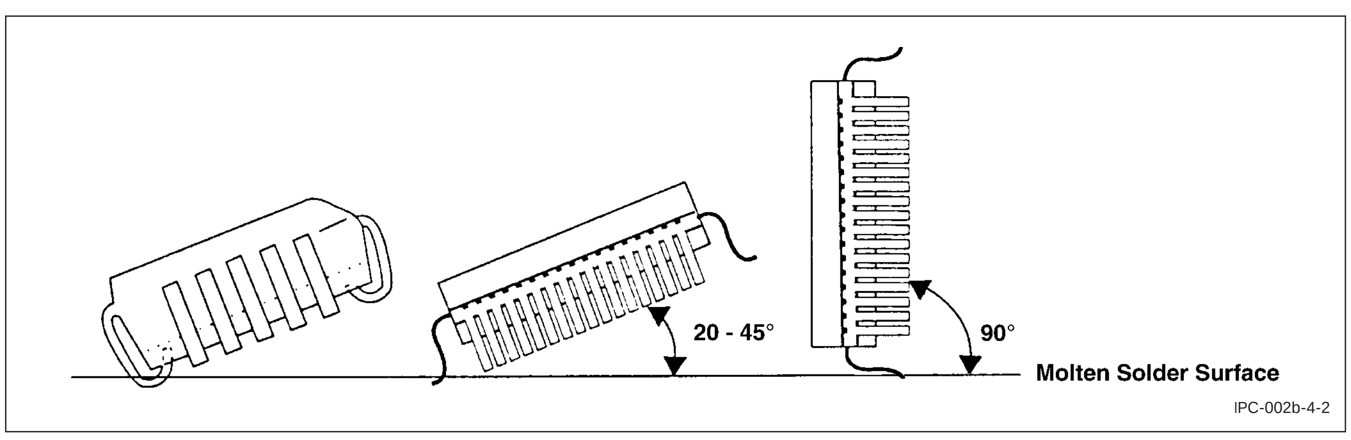


Figure 4-2 Solder Dipping Angle for Surface Mount Leaded Components

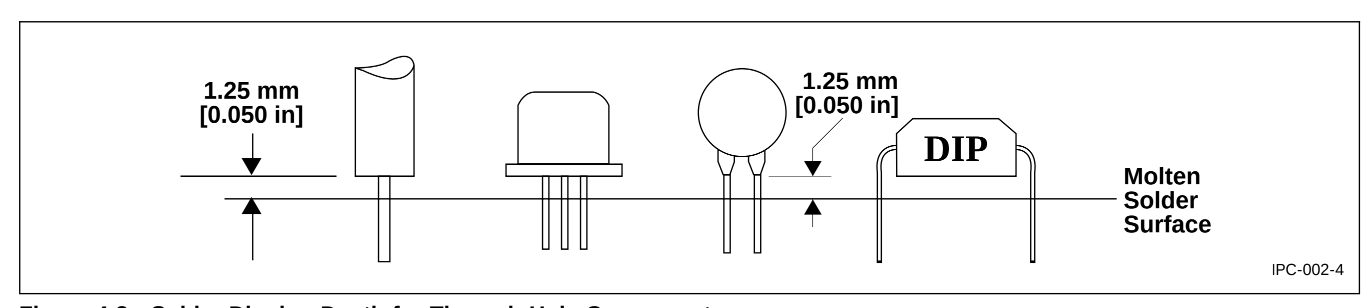


Figure 4-3 Solder Dipping Depth for Through-Hole Components

e. Before examination, all leads **shall** have all visible flux residues removed per 3.2.3.

4.2.1.4 Evaluation

4.2.1.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3. For fine pitch leaded parts (0.5 mm [0.019 in] pitch or less) the inspection magnification **shall** be 30X.

4.2.1.4.2 Accept/Reject Criteria All leads **shall** exhibit a continuous solder coating free from defects for a minimum of 95% of the critical area of any individual lead. Anomalies other than dewetting, nonwetting, and pin holes are not cause for rejection (see Appendices A and B).

4.2.2 Test B – Solder Bath/Dip and Look Test (Leadless Components) This test is for solder bath/dip and look testing of leadless components.

4.2.2.1 Apparatus

4.2.2.1.1 Solder Pot/Bath A solder vessel that meets the requirements of 3.3.2 **shall** be used. The solder **shall** meet the requirements of 3.2.1. Solder bath temperatures and solder contamination control **shall** be in accordance with 3.5.1 and 3.5.2.

4.2.2.1.2 Vertical Dipping Device A mechanical or electro-mechanical dipping device similar to the device shown in Figure 4-1 **shall** be used unless otherwise agreed to between user and vendor. The rate of immersion, dwell time, and rate of withdrawal **shall** be within the test limits defined in 4.2.2.3. Surface mount leadless components **shall** be immersed between 20° and 45° to the solder surface.

4.2.2.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

4.2.2.3 Procedure

a. Dross and burned flux **shall** be skimmed from the surface of the molten solder immediately before dipping.

b. The fluxed specimen **shall** be immersed in the molten solder 0.10 mm [0.0039 in] minimum (see Figure 4-4). Immerse and withdraw at 25 ± 6 mm [0.984 ± 0.24 in] per second and dwell for 5 +0/-0.5 seconds (see 5.3). Massive components may require a longer molten solder dwell time (see 5.3).

c. After withdrawal, the solder **shall** be allowed to solidify by air cooling while the specimen is maintained in the test attitude.

d. Before examination, all terminations **shall** have all visible flux residues removed per 3.2.3.

4.2.2.4 Evaluation

4.2.2.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3. For fine pitch termination parts (0.5 mm [0.020 in] pitch or less) the inspection magnification **shall** be 30X.

4.2.2.4.2 Accept/Reject Criteria All terminations **shall** exhibit a continuous solder coating free from defects for a minimum of 95% of the critical area of any individual termination. Anomalies other than dewetting, nonwetting, and pin holes are not cause for rejection (see Appendices A and B).

4.2.3 Test C – Wrapped Wire Test (Lugs, Tabs, Terminals, Large Stranded Wire) This test is for wrapped wire testing of lugs, tabs, terminals, stranded wire greater than No. 18 AWG size, and solid wire greater than 1.143 mm [0.045 in] diameter.

4.2.3.1 Apparatus

4.2.3.1.1 Solder Pot/Bath A solder vessel that meets the requirements of 3.3.2 **shall** be used. The solder **shall** meet the requirements of 3.2.1. Solder bath temperatures and solder contamination control **shall** be in accordance with 3.5.1 and 3.5.2.

4.2.3.1.2 Dipping Device A mechanical or electro-mechanical dipping device similar to the device shown in Figure 4-1 **shall** be used unless otherwise agreed to between user and vendor. The rate of immersion, dwell time, and rate of withdrawal **shall** be within the test limits defined in 4.2.3.3. Wobble, vibration, and other extraneous movements **shall** be minimized.

4.2.3.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

a. For application of standard solderable wire for lugs, tabs, terminals, stranded wire greater than No. 18 AWG size, and solid wire greater than 1.15 mm [0.045 in] diameter all specimens **shall** have a wrap of 1.5 turns of the standard wire around the portion of the specimen to be tested.

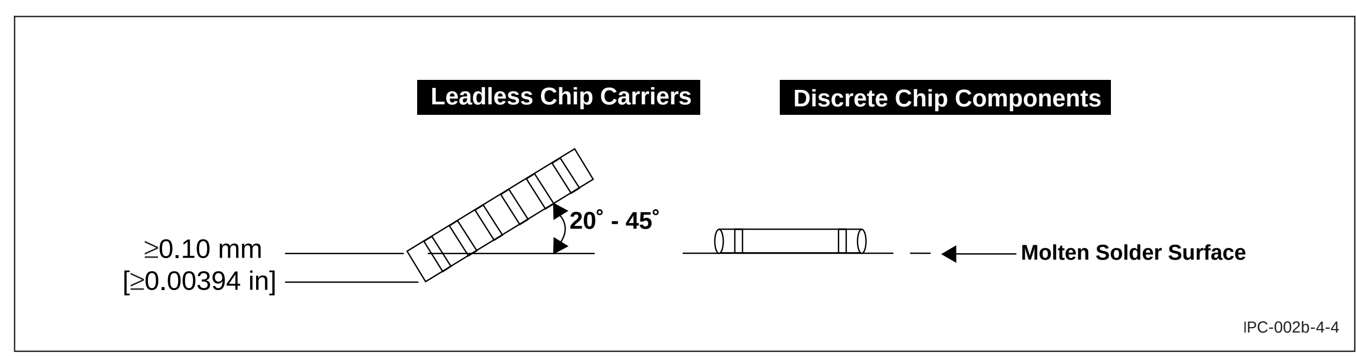


Figure 4-4 Leadless Component Immersion Depth

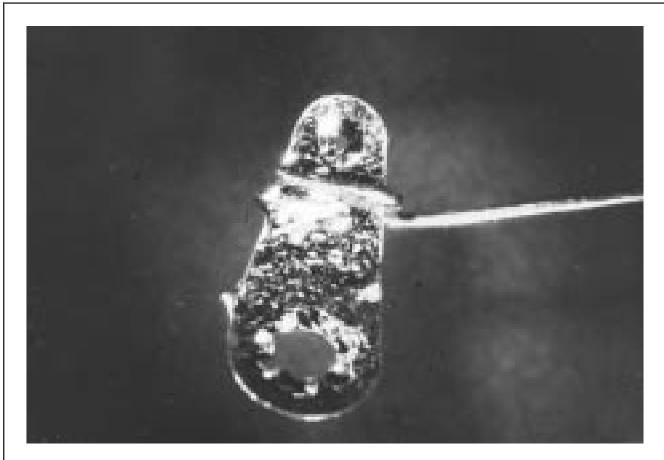


Illustration of Acceptable Solderable Terminal

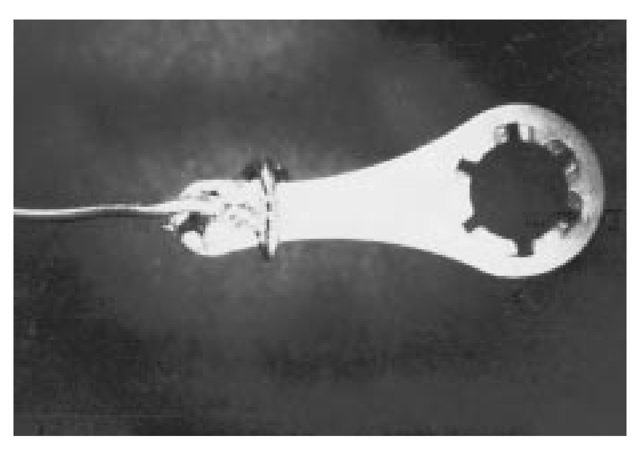


Illustration of Unsolderable Terminal



Illustration of Acceptable Solderable Stranded Wire



Illustration of Partially Solderable Stranded Wire Showing Incomplete Fillet

IPC-002b-4-5a, 4-5b, 4-5c, 4-5d

Figure 4-5

b. The standard wrapping wire as described in 3.2.4, **shall** be wrapped in such a manner so that it will not move during the solder dip. Examples of this wrap are shown in Figure 4-5.

c. Special instructions concerning the portion of the specimens to be wrapped **shall** be specified in the individual specification, if necessary.

d. For lugs and tabs designed to accept wire smaller than 0.6 mm [0.024 in] diameter, the standard copper wrapping wire specified in 3.2.4 **shall** be the same size for which the lugs and tabs are designed.

4.2.3.3 Procedure

a. The flux **shall** be at room ambient temperature (see 3.2.2).

b. Terminations **shall** be immersed in the flux to the minimum depth necessary to cover the surface to be tested.

c. The surface to be tested **shall** be immersed for 5 to 10 seconds and allowed to drain for 10 to 60 seconds.

d. The dross and burned flux **shall** be skimmed from the surface of the molten solder just before immersing the terminations in the solder.

e. The part **shall** be attached to a dipping device and the flux-covered terminations immersed once in the molten solder to the same depth specified in 4.2.3.3b.

f. Immerse and withdraw at a rate of 25 ± 6 mm [0.984 ± 0.24 in] per second and dwell for 7 ± 0.50 seconds.

g. After the dipping process, the part **shall** be allowed to cool in air.

4.2.3.3.3 Before examination, all terminations **shall** have all visible flux residue removed per 3.2.3.

4.2.3.4 Evaluation

4.2.3.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3.

4.2.3.4.2 Accept/Reject Criteria The criteria for acceptable solderability of lugs, tabs, terminals, stranded wire greater than #18 AWG: 1.143 mm [0.045 in] diameter are:

a. Ninety-five percent of the total length of fillet between wrap wire and termination **shall** be tangent to the surface of the termination and be free of anomalies such as pinholes.

b. A ragged or interrupted tangency line indicates a defect.

In case of dispute, the percent of fillet-length with defects **shall** be determined by their actual measurement. Figure B4 is included as an aid in the evaluation of the 5% allowable defects.

4.2.4 Test D – Resistance to Dissolution of Metallization Test This test is to reveal a susceptibility to loss of solderability due to either:

a. dissolution of metallization over unsolderable base material (as indicated by loss of wetting), or

b. accumulation of impurities from the basis metal (as indicated by dewetting).

4.2.4.1 Apparatus

4.2.4.1.1 Solder Pot/Bath A solder vessel that meets the requirements of 3.3.2 **shall** be used. The solder **shall** meet the requirements of 3.2.1. Solder bath temperatures and solder contamination control **shall** be in accordance with 3.5.1 and 3.5.2.

4.2.4.1.2 Dipping Device A mechanical or electro-mechanical dipping device similar to the device shown in Figure 4-1 **shall** be used unless otherwise agreed to between user and vendor. The rate of immersion, dwell time, and rate of withdrawal **shall** be within the test limits defined in 4.2.4.3.

4.2.4.1.3 Attitude (Angle of Immersion) All components **shall** be dipped using a vertical motion to ensure complete immersion of the surfaces to be soldered.

4.2.4.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

4.2.4.3 Procedure

a. Dross and burned flux **shall** be skimmed from the surface of the molten solder immediately before dipping.

b. The flux-covered termination **shall** be immersed only once in the molten solder to a minimum depth to completely cover the termination being tested.

c. The angle of immersion **shall** be between 20° and 45°.

d. Immerse and withdraw at a rate of 25 ± 6 mm [0.984 ± 0.24 in] per second and dwell for 7 ± 0.50 seconds.

4.2.4.4 Accept/Reject Criteria The criteria for acceptable resistance to leaching/dewetting **shall** be that no more than 5% of the solderable termination exhibits exposed underlying, nonwettable base metal or metallization layers or portions of the ceramic substrate after exposure to molten solder.

4.2.4.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3. For fine pitch termination parts (0.5 mm [0.020 in] pitch or less) the inspection magnification **shall** be 30X.

4.2.5 Test S – Surface Mount Process Simulation Test This test simulates actual surface mount component performance in a reflow process.

4.2.5.1 Apparatus

4.2.5.1.1 Stencil/Screen A stencil or screen with pad geometry openings that is appropriate for the terminals being tested **shall** be used. Unless otherwise agreed upon between vendor and user the nominal stencil thickness **shall** be per Table 4-1.

Table 4-1 Stencil Thickness Requirements

Nominal Stencil Thickness	Component Lead Pitch
0.10 mm [0.00394 in]	<0.508 mm [<0.020 in]
0.15 mm [0.00591 in]	0.508-0.635 mm [0.020-0.025 in]
0.20 mm [0.00787 in]	>0.635 mm [>0.025 in]

4.2.5.1.2 Paste Application Tool A rubber or metal squeegee device **shall** be used to distribute paste across stencil/screen.

4.2.5.1.3 Test Substrate A ceramic substrate 0.635 mm [0.025 in] nominal thickness **shall** be used for testing. Other nonwettable substrates may be used if agreed upon between vendor and user.

4.2.5.1.4 Reflow Equipment An IR/convection reflow oven, vapor phase reflow system, or storage oven capable of reaching the reflow temperature of the paste **shall** be used. Unless otherwise agreed upon between vendor and user the reflow parameters **shall** be per Table 4-2.

Table 4-2 Reflow Parameter Requirements

	Temperature	Time
Vapor Phase Reflow	215-219°C [419-426°F	30-60 seconds dwell at reflow
IR/Convection Reflow	150-170°C [302-338°F] Preheat 215-230°C [419-446°F] Reflow	50-70 seconds 50-70 seconds
Storage Oven	215-230°C [419-446°F]	2-5 minutes (until reflow is assured)

4.2.5.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

4.2.5.3 Procedure

a. Place solder paste onto stencil/screen and print the terminal pattern onto the test substrate by wiping paste over the stencil/screen in one smooth motion using rubber or metal squeegee (see 3.2.1).

b. Remove the stencil/screen carefully so as to avoid smearing the paste print.

c. Verify a paste print equivalent in geometry to the terminal of the device to be tested.

d. Place the terminals of the component being tested on the solder paste print.

e. Verify component placement by appropriate magnification.

f. Place test substrate on applicable reflow equipment and conduct reflow process.

g. After reflow, carefully remove substrate with component(s) and allow to cool to room temperature.

h. Remove component(s) from substrate. Component leads may adhere slightly to substrate due to flux residue.

i. Before examination, all leads **shall** have all visible flux residues removed per 3.2.3. Care should be exercised in flux residue removal process to not damage leads.

4.2.5.4 Evaluation

4.2.5.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3. For fine pitch leaded/termination parts (0.5 mm [0.020 in] pitch or less) the inspection magnification **shall** be 30X.

4.2.5.4.2 Accept/Reject Criteria All leads **shall** exhibit a continuous solder coating free from defects for a minimum of 95% of the critical area of any individual lead. Anomalies other than dewetting, nonwetting, and pinholes are not cause for rejection (see Appendices A and B). Exposed terminal metal is allowable on the toe end of surface mount components.

4.3 Tests without Established Accept/Reject Criteria

4.3.1 Test E – Wetting Balance Test (Leaded Components) This test is for wetting balance testing of leaded components.

4.3.1.1 Apparatus A solder meniscus force measuring device (wetting balance) which includes a temperature controlled solder pot containing solder per 3.2.1 and maintained per 3.5.1 and 3.5.2 **shall** be used. The equipment **shall** have a means of recording force as a function of time, such as a chart recorder, data logger, or computer (see Figure 4-6).

4.3.1.1.1 Dipping Device A mechanical or electromechanical dipping device incorporated in the wetting balance **shall** be used. The device **shall** be preset to produce an immersion and emersion rate as specified in 4.3.1.3. The specimen dwell time is controlled to the time specified in 4.3.1.3. A device to sense contact of the lead(s) with the molten solder bath **shall** also be part of the fixture or instrument.

4.3.1.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

4.3.1.3 Procedure

a. Flux per 3.2.2 **shall** be used. The flux **shall** be at room temperature.

b. Leads and terminations **shall** have flux applied uniformly, necessary to cover the surfaces to be tested.

c. Dross and burned flux **shall** be skimmed from the surface of the molten solder immediately before dipping.

d. The flux covered termination **shall** be immersed only once in the molten solder to a depth of 0.10 mm [0.0039 in].

e. The angle of immersion **shall** be 20° - 45° (see Figure 4-2).

f. Immerse and withdraw at 1 mm - 5 mm [0.04 ± 0.20 in] per second and dwell for 5 +0/-0.5 seconds. Massive components may require a longer solder dwell time (see 5.3).

4.3.1.4 Evaluation This test is intended for evaluation purposes only (see 1.3).

4.3.1.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3. For fine pitch leaded/termination parts (0.5 mm [0.020 in] pitch or less) the inspection magnification **shall** be 30X.

4.3.1.4.2 Suggested criteria for solderability evaluation for Test E are listed in Table 4-3. Figures 4-7 and 4-8 illustrate the suggested criteria of Table 4-3. In addition, the area of the test sample with fresh solder adhesion **shall** be greater than the area that was immersed in the solder bath, (i.e., the component **shall** exhibit positive wicking beyond its immersion depth).

4.3.2 Test F – Wetting Balance Test (Leadless Components) This test is for wetting balance testing of leadless components.

4.3.2.1 Apparatus A solder meniscus force measuring device (wetting balance) which includes a temperature controlled solder pot containing solder per 3.2.1 and maintained per 3.5.1 and 3.5.2 **shall** be used. The equipment **shall** have a means of recording force as a function of time, such as a chart recorder, data logger, or computer (see Figure 4-6).

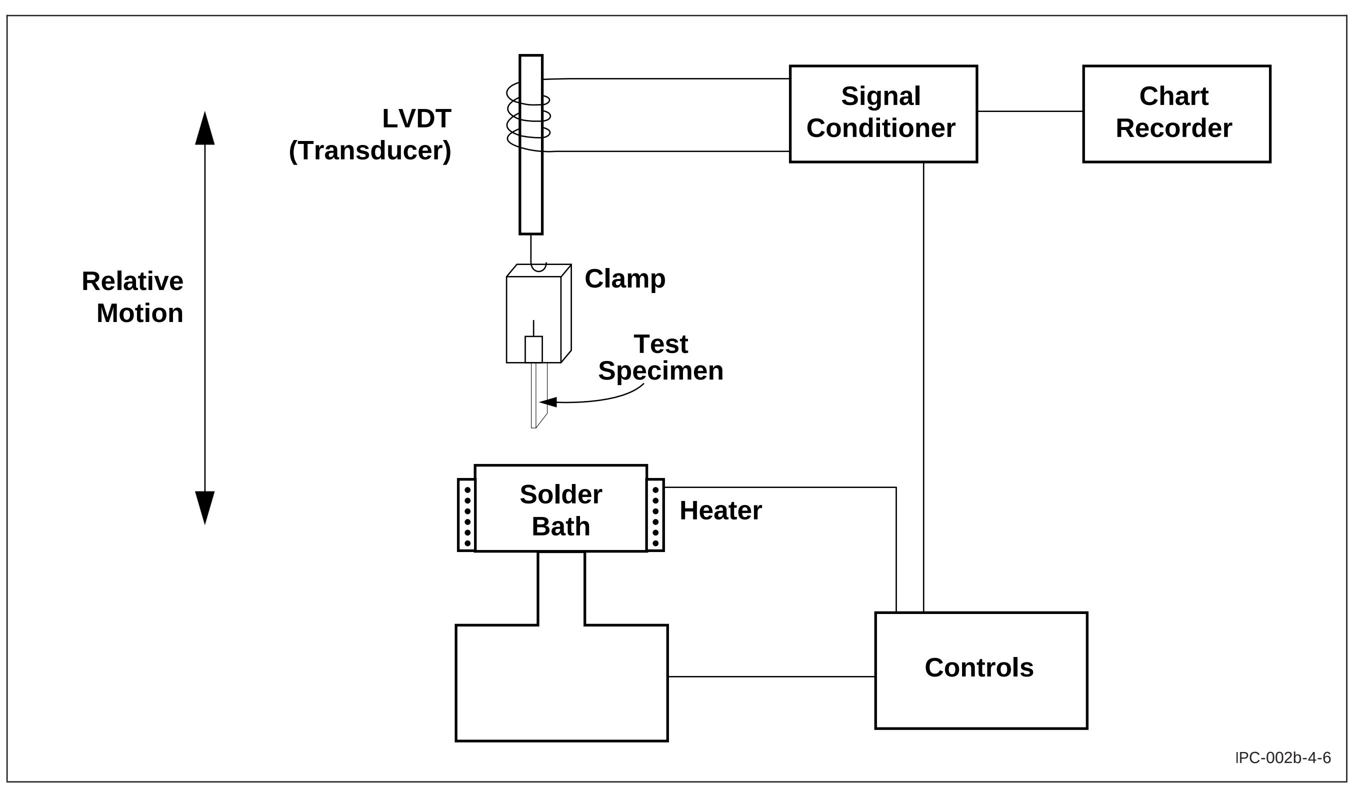


Figure 4-6 Wetting Balance Apparatus

Table 4-3 Wetting Balance Parameter and Suggested Evaluation Criteria

Parameter	Description	Suggested Criteria[1]	
		Set A	Set B
T_0	Time to buoyancy corrected zero	≤1 second	≤2 seconds
F2	Wetting force at two seconds from start of test	50% of maximum theoretical wetting force at or before two seconds[2]	Positive value at or before two seconds
F5	Wetting force at five seconds from start of test	At or above the positive value of F2	At or above the value of F2
AA	Integrated value of area of the wetting curve from start of test	Area calculated using sample buoyancy and 50% maximum theoretical force[3]	> zero (0)

1. This suggested criteria has been established as a two-tier evaluation format with Set A being more stringent. Components meeting Set A suggested criteria are applicable to a larger soldering process window than components meeting Set B suggested criteria. It should be recognized that components meeting Set B suggested criteria may be completely acceptable to a larger process window but the user must determine which criteria set best integrates into their process.
2. See Appendix C for the method of calculating the maximum theoretical force.
3. See Appendix D for the method of calculation. (It is suggested that this method of calculation be programmed into the software used for control of the wetting balance test equipment.)

4.3.2.1.1 Dipping Device A mechanical or electro-mechanical dipping device incorporated in the wetting balance **shall** be used. The device **shall** be preset to produce an immersion and emersion rate as specified in 4.3.2.3. The specimen dwell time is controlled to the time specified in 4.3.2.3.

4.3.2.2 Preparation Specimen preparation **shall** be in accordance with 3.4.

4.3.2.3 Procedure

a. Flux per 3.2.2 **shall** be used.

b. Leads and terminations **shall** have flux applied uniformly, necessary to cover the surfaces to be tested.

c. The flux **shall** be at room temperature.

d. After application of the flux and post dip dwell, the specimen **shall** be mounted on the test equipment.

e. Dross and burned flux **shall** be skimmed from the surface of the molten solder immediately before dipping.

f. The flux covered termination **shall** be immersed only once in the molten solder to a depth of 0.10 mm [0.0039 in] minimum.

g. The angle of immersion **shall** be per Figure 4-4.

h. Immerse and withdraw at 1 mm - 5 mm [0.04 in - 0.20 in] per second and dwell for 5 +0/-0.5 seconds. Massive

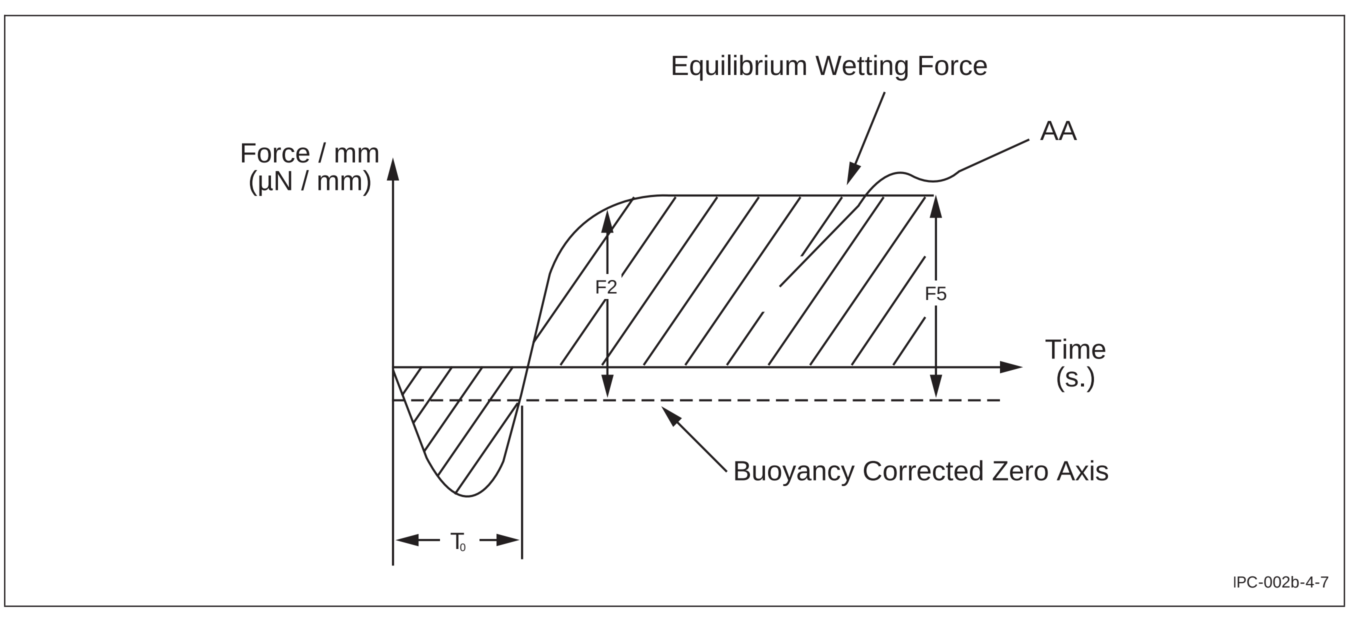


Figure 4-7 Set A Wetting Curve

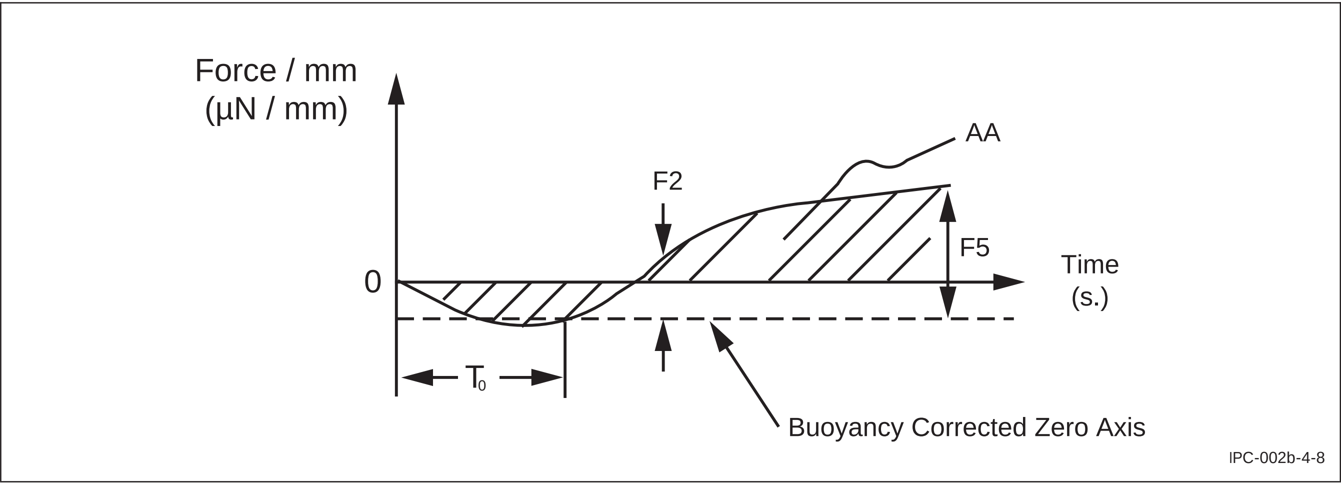


Figure 4-8 Set B Wetting Curve

components may require a longer solder dwell time (see 5.3).

i. A full curve **shall** be recorded using the equipment specified in 4.3.2.1.

4.3.2.4 Evaluation This test is intended for evaluation purposes only (see 1.3).

4.3.2.4.1 Magnification Parts **shall** be examined at 10X using the equipment specified in 3.3.3. For fine pitch termination parts (0.5 mm [0.020 in] pitch or less) the inspection magnification **shall** be 30X.

4.3.2.4.2 Suggested criteria for solderability evaluation for Test F are listed in Table 4-3. Figures 4-7 and 4-8 illustrate the suggested criteria of Table 4-3. In addition, the area of the test sample with fresh solder adhesion **shall** be greater than the area that was immersed in the solder bath (i.e., the component **shall** exhibit positive wicking beyond its immersion depth).

5 NOTES

5.1 Test Equipment Sources The equipment sources described below represent those currently known to the industry. Users of this document are urged to submit additional source names as they become available, so that this list can be kept as current as possible.

5.1.1 Tests A, B, C, D

HMP Soldermatics, P.O. Box 948, Canon City, CO 81215, (719)275-1531

Robotic Process Systems, 23301 E. Mission Ave., Liberty Lake, WA 99019, (509)891-1680

Reef Engineering, Unit 6, Bancrofts Road, South Woodham Ferrers, Essex CM3 5UQ 01245 328123

5.1.2 Tests E & F

Convey AB, Harpsundsvagen 113, S-12458 Bandhagen, Sweden 46 (0) 8 99 66 25

Metronelec, 54, Route de Sartrouville - Le Montreal 78232 Le PECO Cedax, France (USA Distributor: Solderability Testing and Solutions Inc., 18 Wildrose Dr., Edgewood, KY 41017, (859) 331-0598

Concoat LTD., Alasan Hous, Albany Park, Frimley Road, Caberley GU16 7PH, England, +44 (0) 1276 691100

5.1.3 Steam Conditioning Equipment

H&H Engineering, Inc., 3612 Wood Duck Circle, Stockton, CA 95206

Robotic Process Systems, 23301 E. Mission Ave., Liberty Lake, WA 99019, (509)891-1680

Zentek Scientific Systems, 3520 Yale Way, Fremont, CA 94538, (510)651-1581

5.1.4 Grid Reticles

Bender Associates, 5030 South Mill Avenue, Suite C-2, Tempe, AZ 85252, (602) 820-0900

5.2 Use of Activated Flux This standard specifies a rosin-based flux with a very specific quantity of activator. The intent of requiring the use of a specific quantity of flux activator is to reduce the variability of test results that were seen with pure rosin flux, enable the solderability testing of nontin component lead metallizations, and provide a realistic solderability testing safety factor by keeping the amount of activator both fixed and less than that used for production soldering. The benefit of using this specified activated solderability testing flux composition was demonstrated by extensive testing, as reported in the J-STD-002B Activated Solderability Test Flux Rationale Committee Letter.

5.3 Massive Components Large components that have terminations with high heat sinking capacity may require longer dwell times to be applied to the dip test (Tests A, B, C) to allow for the slower heat up time. In such cases an agreement to increase the dwell time will be required between the user and vendor. This agreement must also state the specific dwell time to be used.

5.4 Sampling Plans Sampling plans **shall** identify the number of components to be randomly selected from a given lot. All leads/terminations of the components selected **shall** be tested for solderability. Each lead of a component must pass for the component to pass. The selection and disposition of solderability test specimens **shall** be per the individual component specification.

5.5 Safety Notes Isopropyl alcohol is flammable. Care must be taken in both usage and storage to keep the isopropyl alcohol from sparks or flames. See the Material Safety-Data Sheets (MSDS) for all solvents. All chemicals **shall** be handled per appropriate data sheets, and disposed of per local regulations. Also see IPC-CS-70.

5.6 Correction for Buoyancy For the wetting balance to obtain wetting force values that are relatable to one another, it is necessary to correct for the variability in specimen sizes, in particular width and thickness. This is done by correcting for the volume of the sample immersed in the solder. The following formula may be used to calculate the buoyant force correction:

$$F_b = d\, g_n\, V$$

where:

d = Density of solder at 245°C (8150 kg/m^3)*

g_n = Acceleration of gravity (9.810 m/s^2)

V = Immersed volume in m^3 (width x thickness x immersion depth)

*For Sn60/Pb40 Alloy

The calculated buoyant force will be in Newtons and will be normalized for wetted perimeter and expressed as microNewtons/mm. As shown in Figures 4-7 and 4-8, using the convention that wetting force is positive upward, all measurements need to be buoyancy corrected for the times as well as the forces to be more accurate.

5.7 Accelerated Steam Conditioning Limitations The accelerated steam conditioning of solderable coatings has been, and continues to be, the subject of intense investigation (see IPC-TR-464). Compared to other conditioning methods, steam conditioning satisfactorily accelerates the degradation of tin and tin/lead surfaces in a manner similar to natural aging. The degradation mechanisms of surface oxidation and Cu/Sn intermetallic growth are both enhanced by the heat and humidity of steam. Properly applied tin and tin/lead coatings can withstand the steam conditioning environment well beyond the eight hours specified and may survive natural aging well beyond 12 months. Due to the combined effects of specific geometry, storage environ-ment, and material systems, it is not possible to accurately predict storage life. As a result, this specification indicates a storage life overlap for coating durability Category 1 and Category 3, and an open ended limit for coating durability Category 3. For coatings other than tin or tin-lead (Category 2) data do not exist to support steam conditioning longer than the one hour specified.

5.8 Referee Magnification Referee magnification **shall** be 30X. For fine pitch leaded parts (0.5 mm [0.020 in] pitch or less) the referee magnification **shall** be 70X. Referee conditions **shall** only be used to accept a product that has been rejected at the inspection magnification.

Appendix A
Critical Component Surfaces

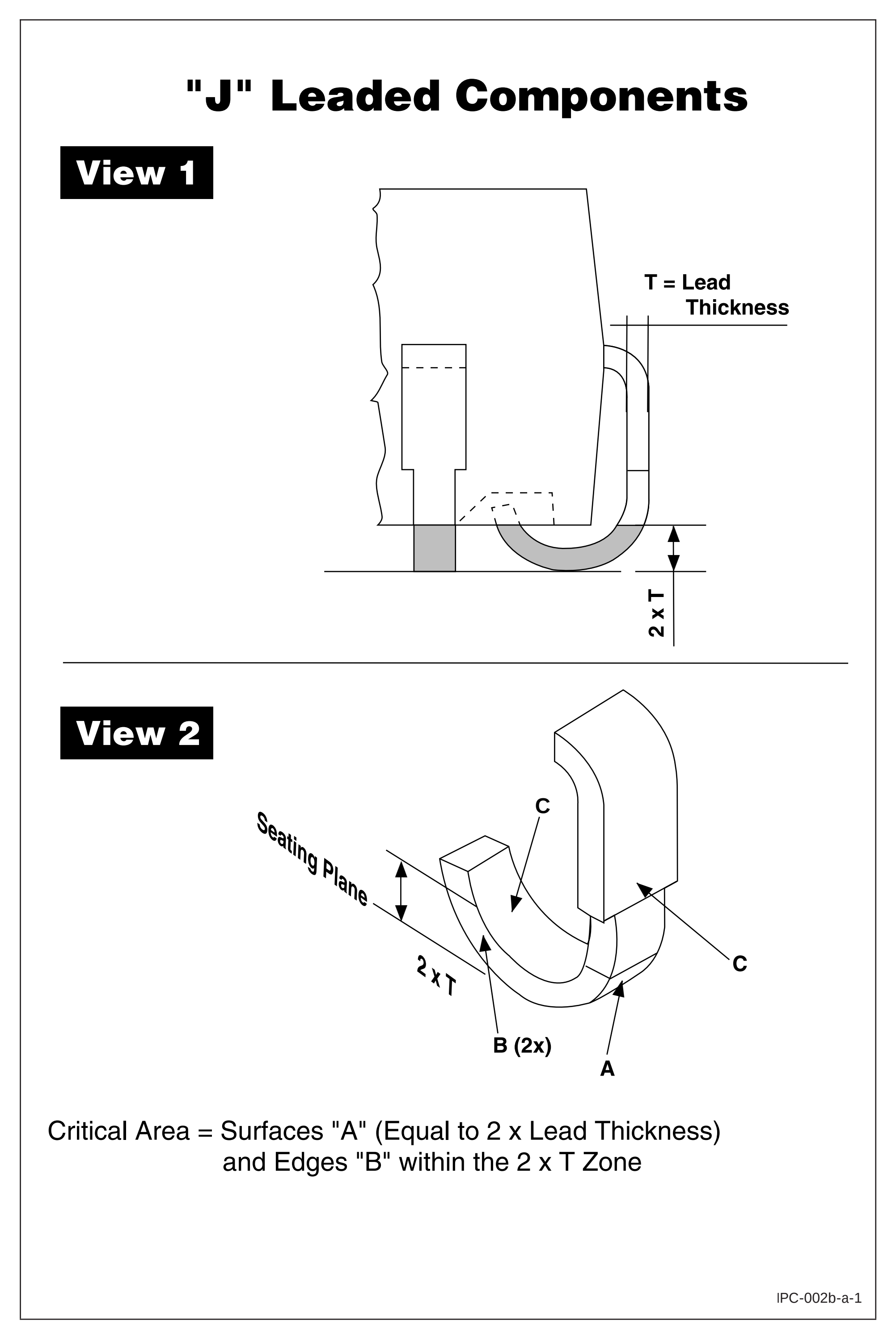


Figure A-1 "J" Leaded Components

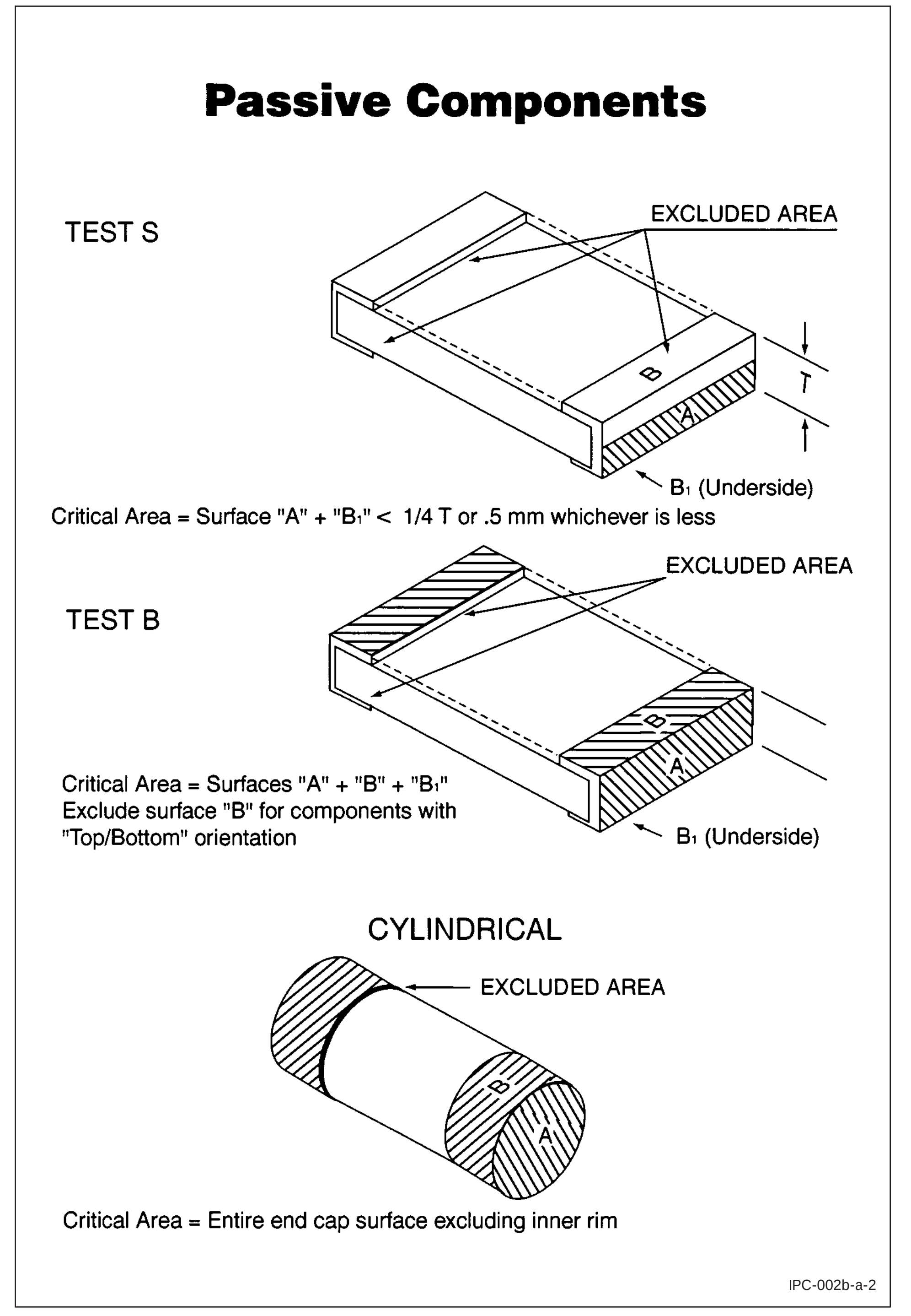


Figure A-2 Passive Components

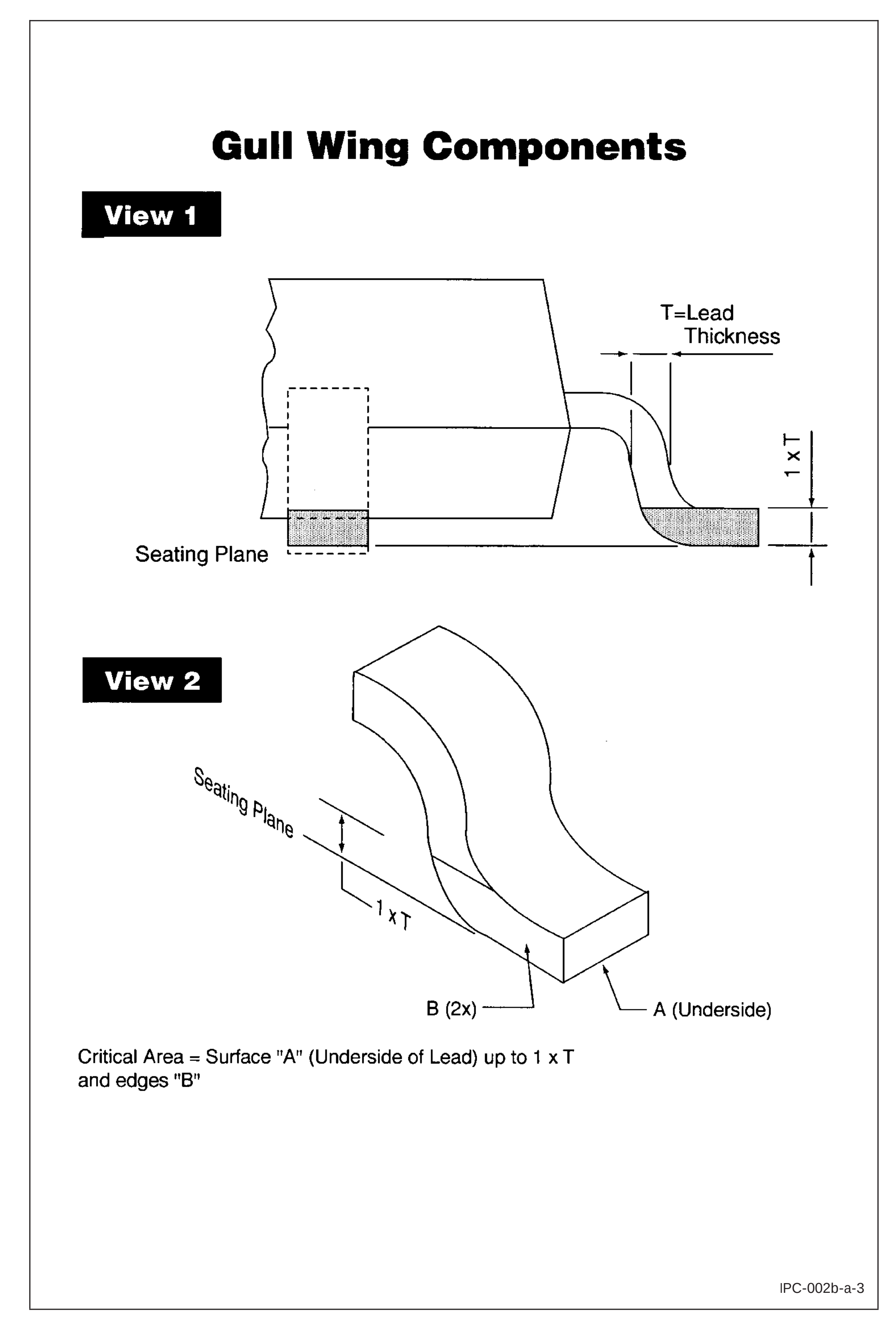


Figure A-3 Gull Wing Components

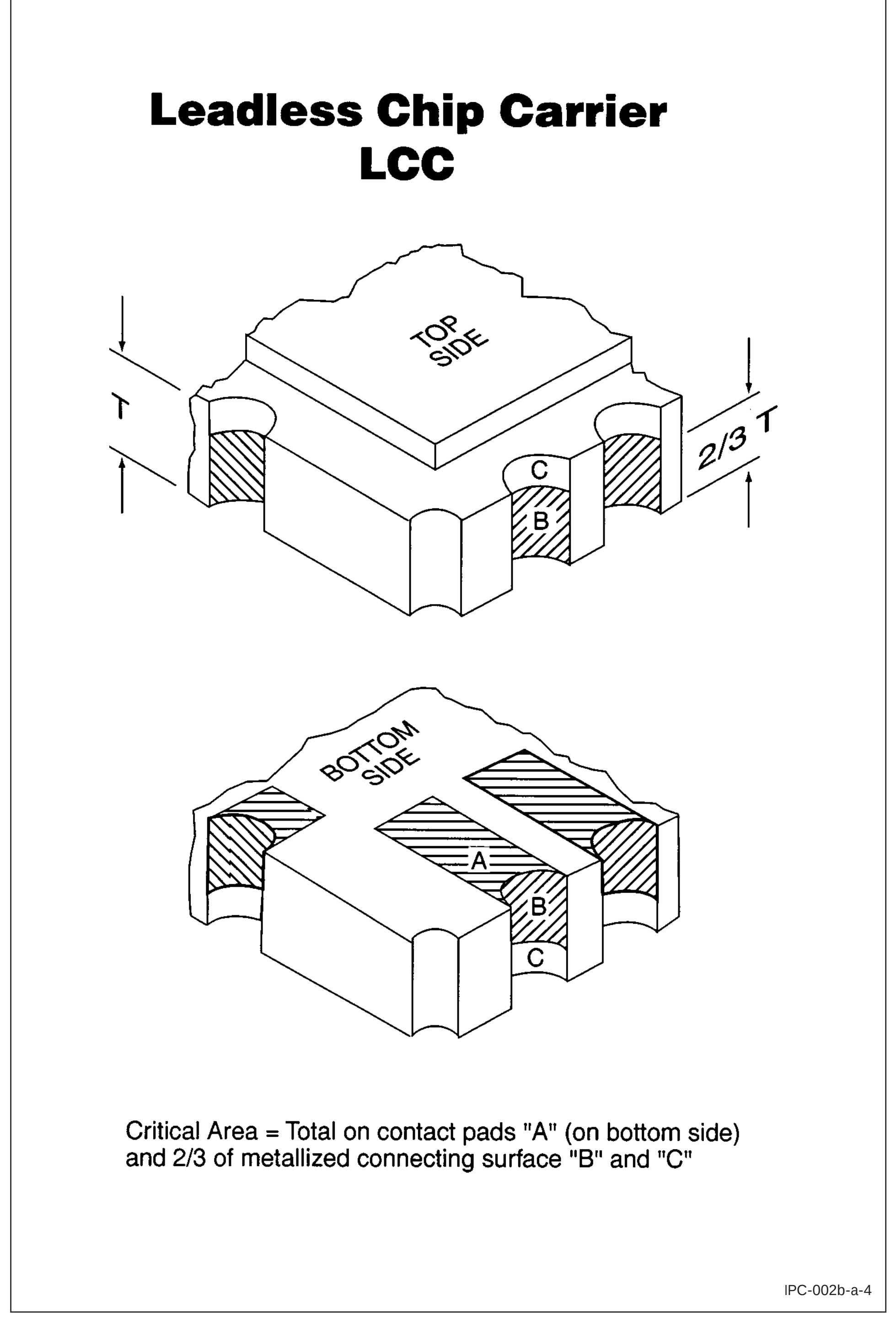


Figure A-4 Leadless Chip Carrier

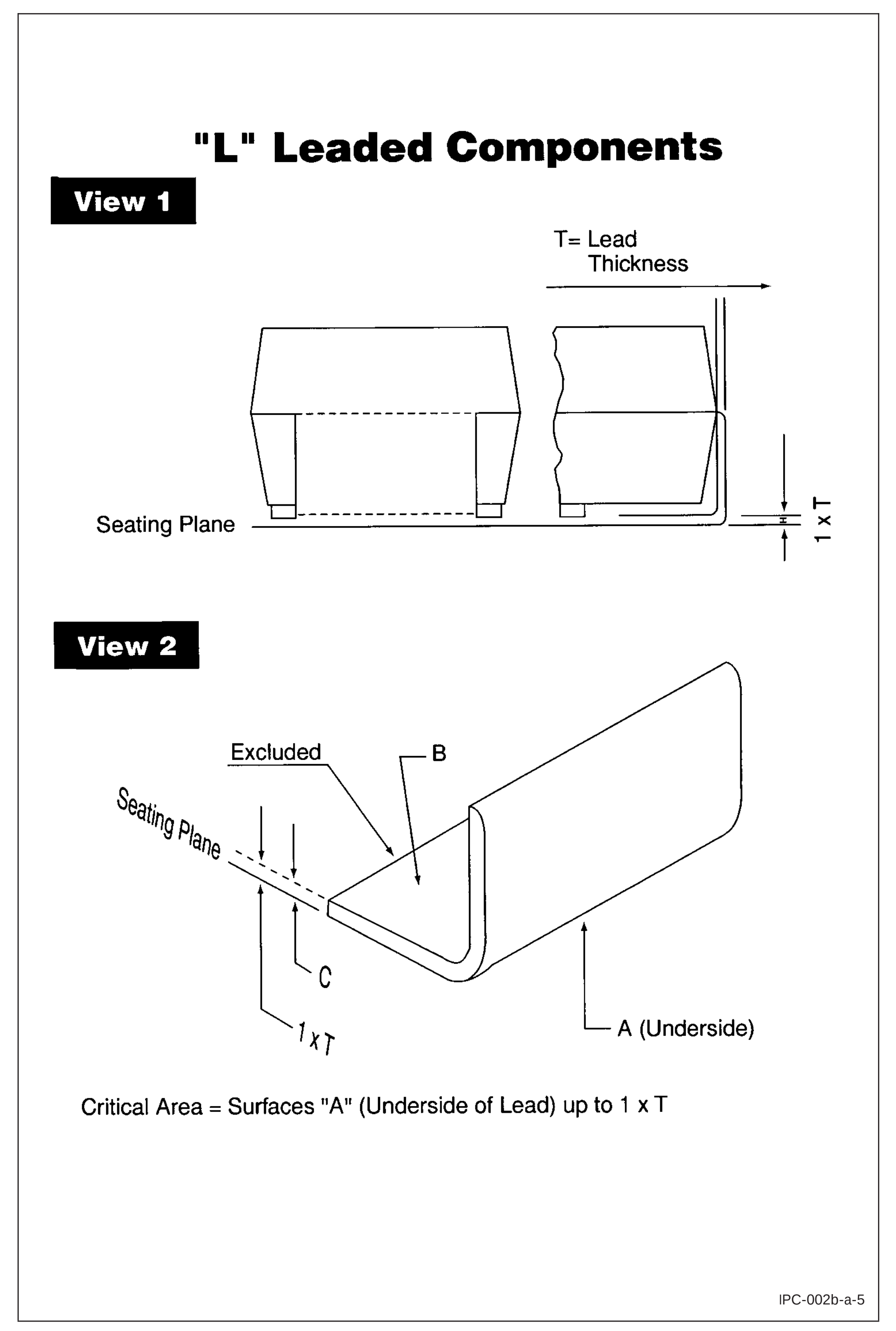


Figure A-5 "L" Leaded Component

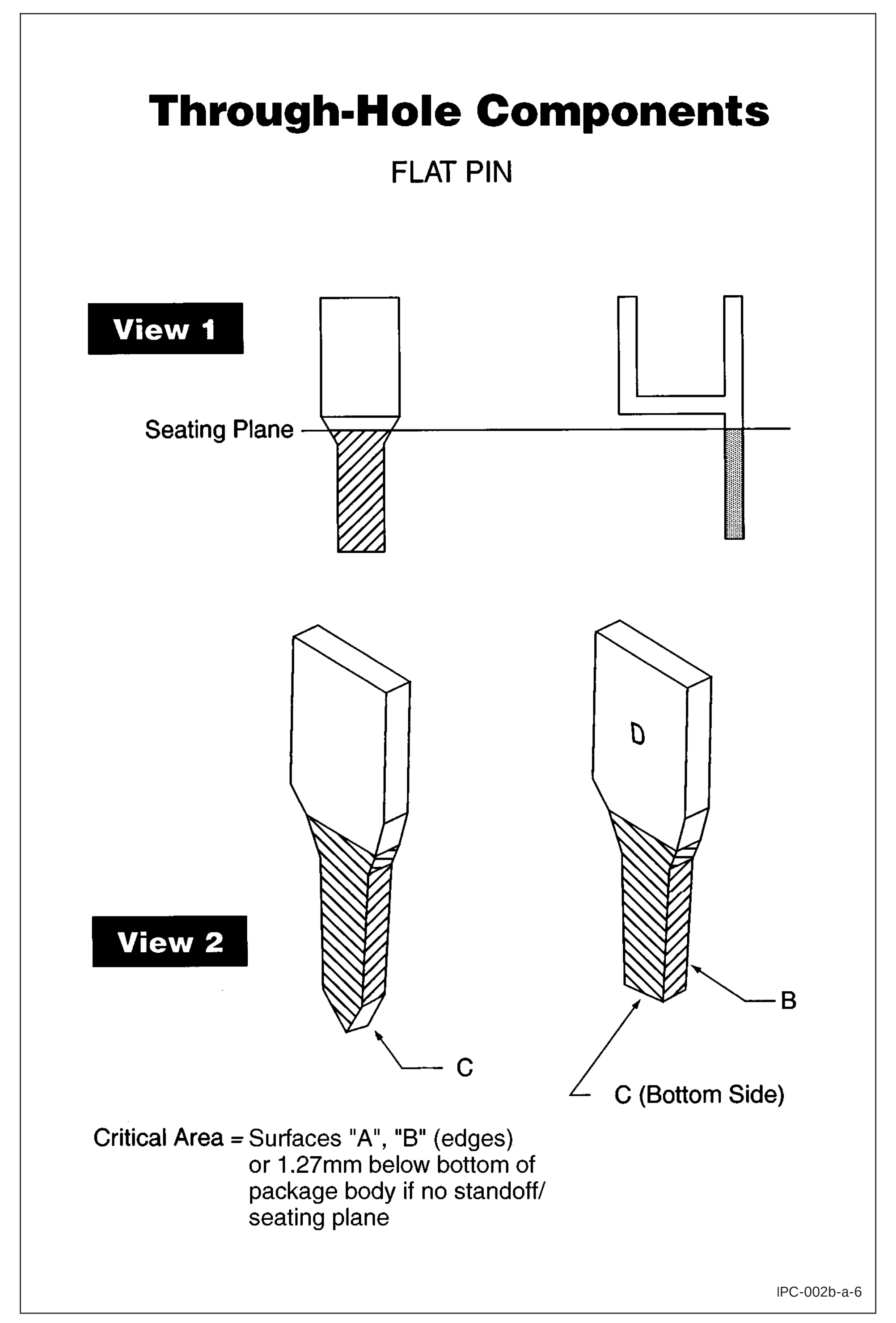


Figure A-6 Through-Hole Components

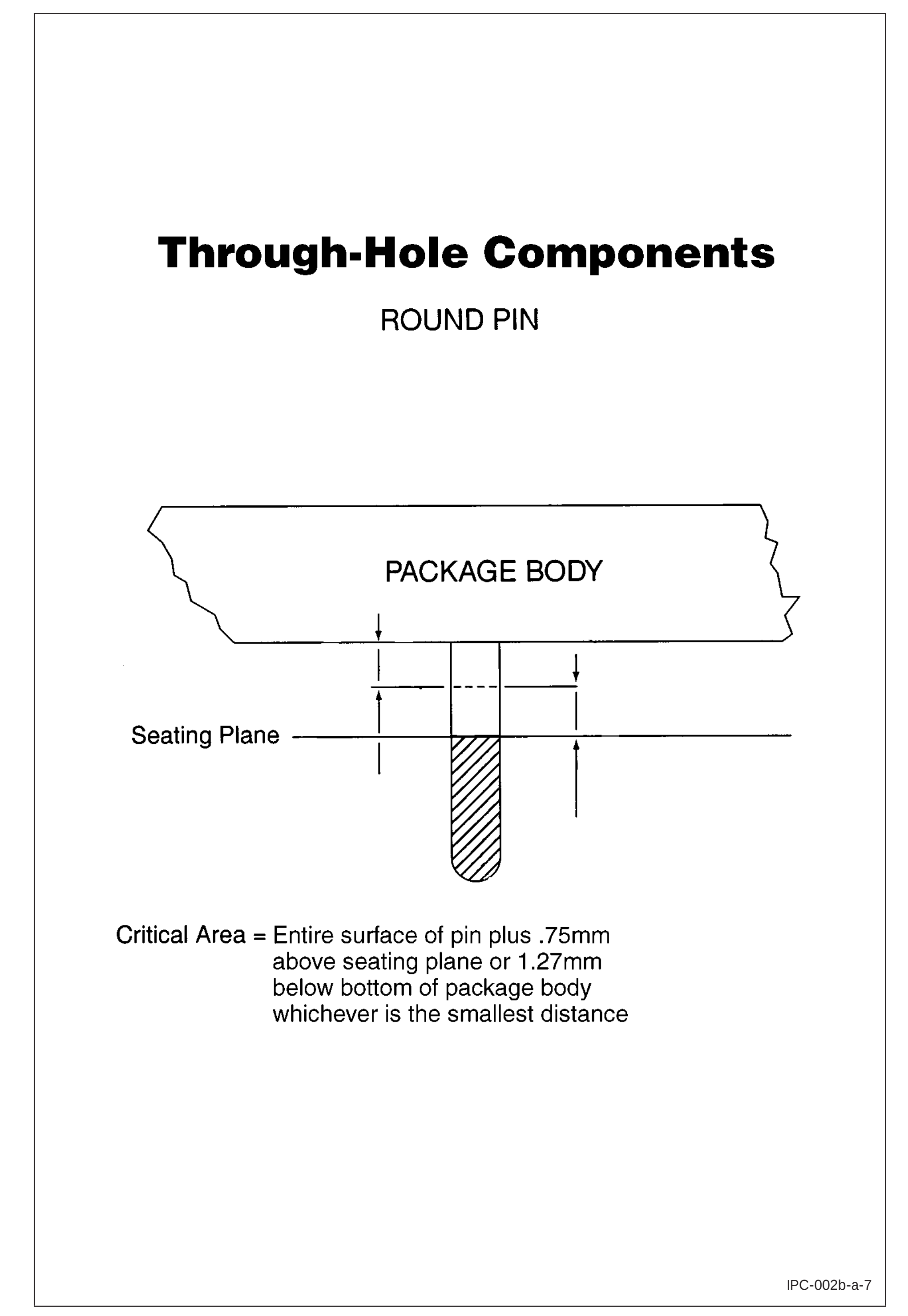


Figure A-7 Through-Hole Components

Appendix B
Evaluation Aids

B.1 Evaluation Aids for Tests A and C

B.2 Round Leads The measurement of defects or the estimation of defect area percentage of the lead total surface area, is more difficult with round leads than it is with flat surface rectangular leads. For example, in viewing a cylindrical surface such as a round lead, a round diameter size defect when flat appears oval shaped and narrower in width than the visible surface of the lead in the transverse direction, which is half of its circumference.

To aid the solderability test inspector in estimating the lead surface percentage after solderability testing, a guide sheet for different diameter leads in Figure B-3. When 25.4 mm of the lead surface of a 0.5 mm diameter lead is inspected for solder coverage, 10 diameter size defects equal 5% of the total lead surface area. Numbers of half diameter size and quarter diameter size defects are also listed. Combinations of these sizes can also be totaled easily (see Figure B-1).

In considering areas not covered by a continuous, new solder coating and referring to the defined defects illustrated in Figure B-2, the visible areas of dewetting and nonwetting are applicable directly.

An example of what constitutes 5% of the dipped area is: six defects of 0.813 mm diameter in a 25.4 mm length of a 0.813 mm diameter (No. 20 AWG) wire (see Figures B-3, B-4 and B-5}.

B.3 Square Terminations Square terminations shall meet the requirements of the solderability coverage guide shown in Figure B-5.

B.4 Castellated Terminations Castellated terminations shall meet the same criterion as round leads.

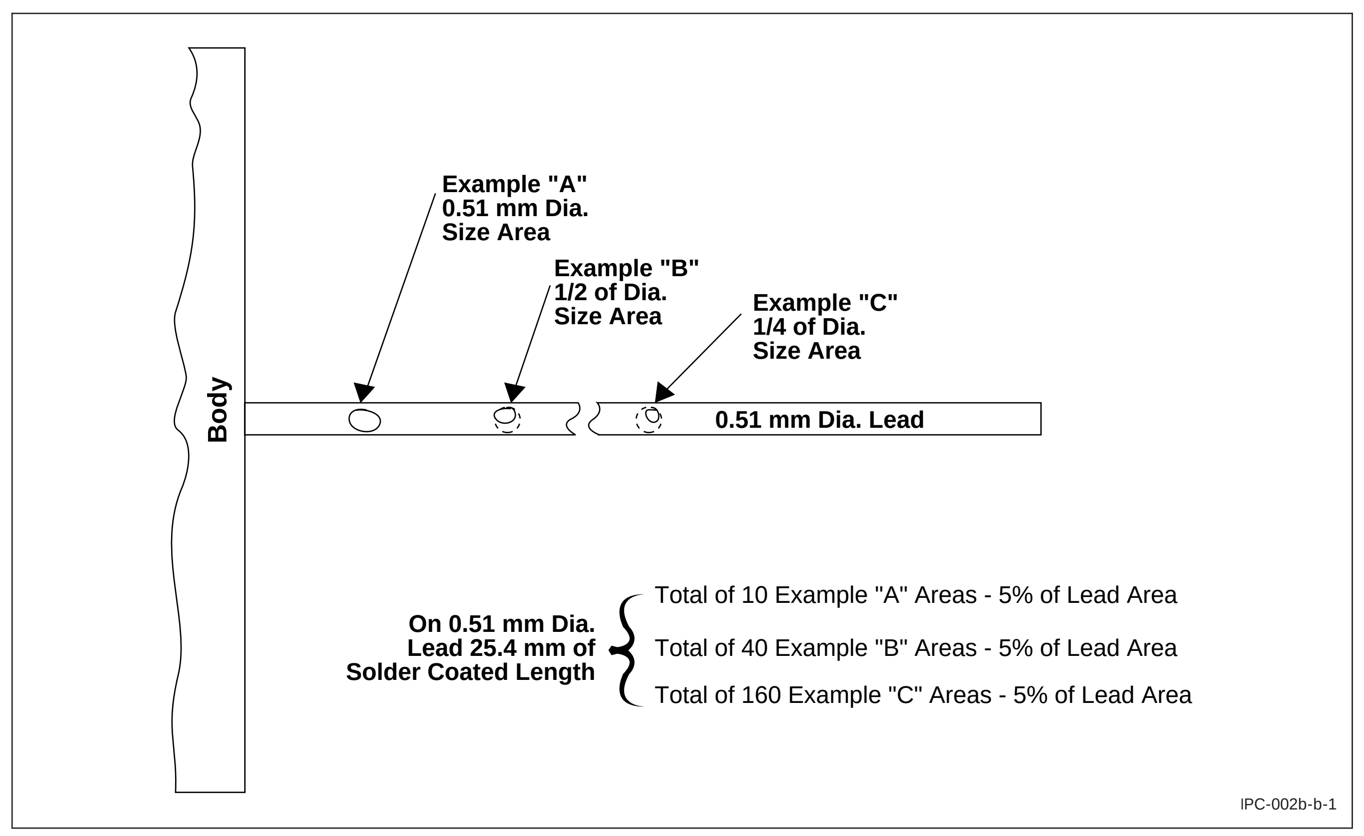
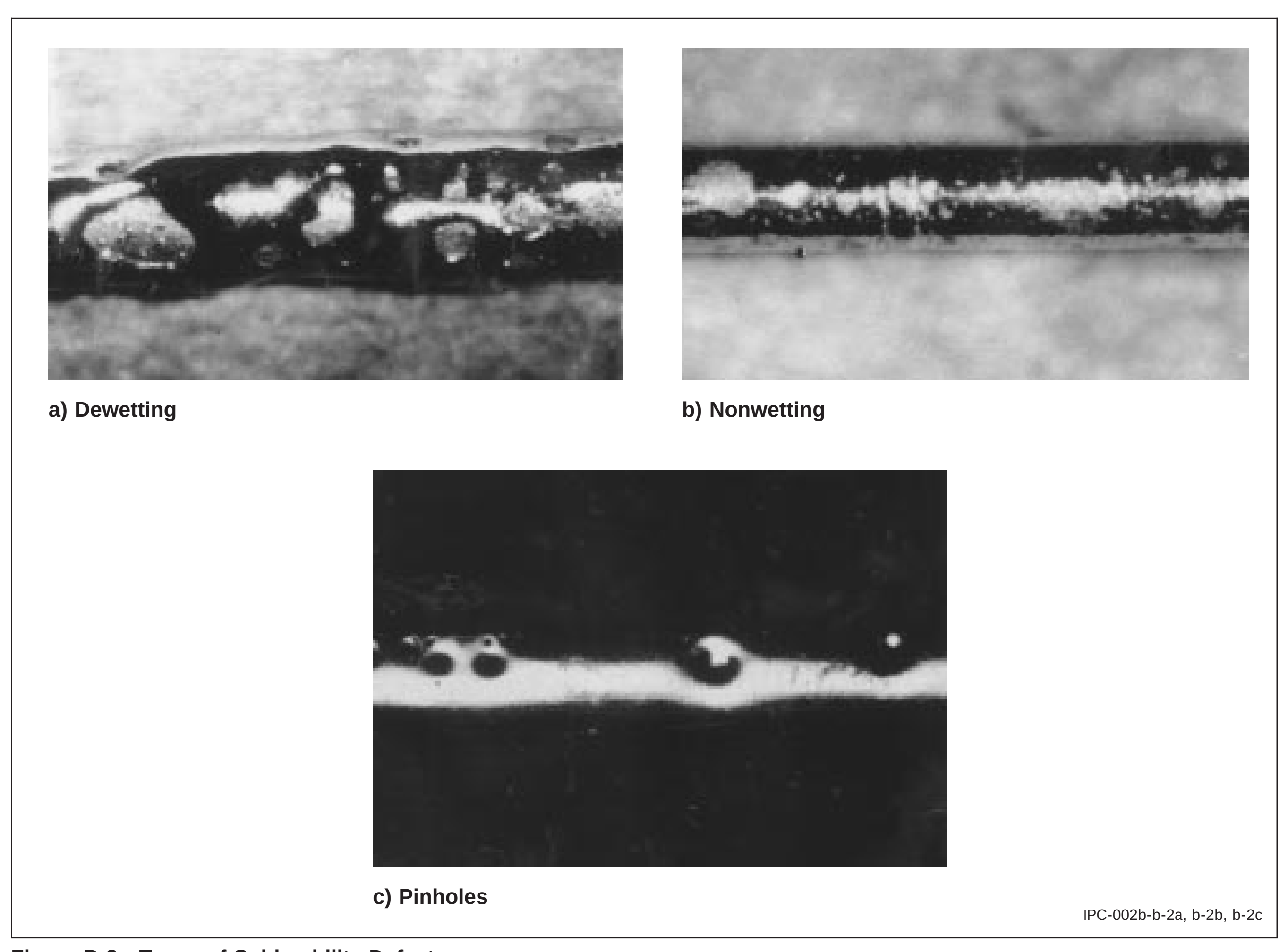


Figure B-1 Defect Size Aid



a) Dewetting

b) Nonwetting

c) Pinholes

Figure B-2 Types of Solderability Defects

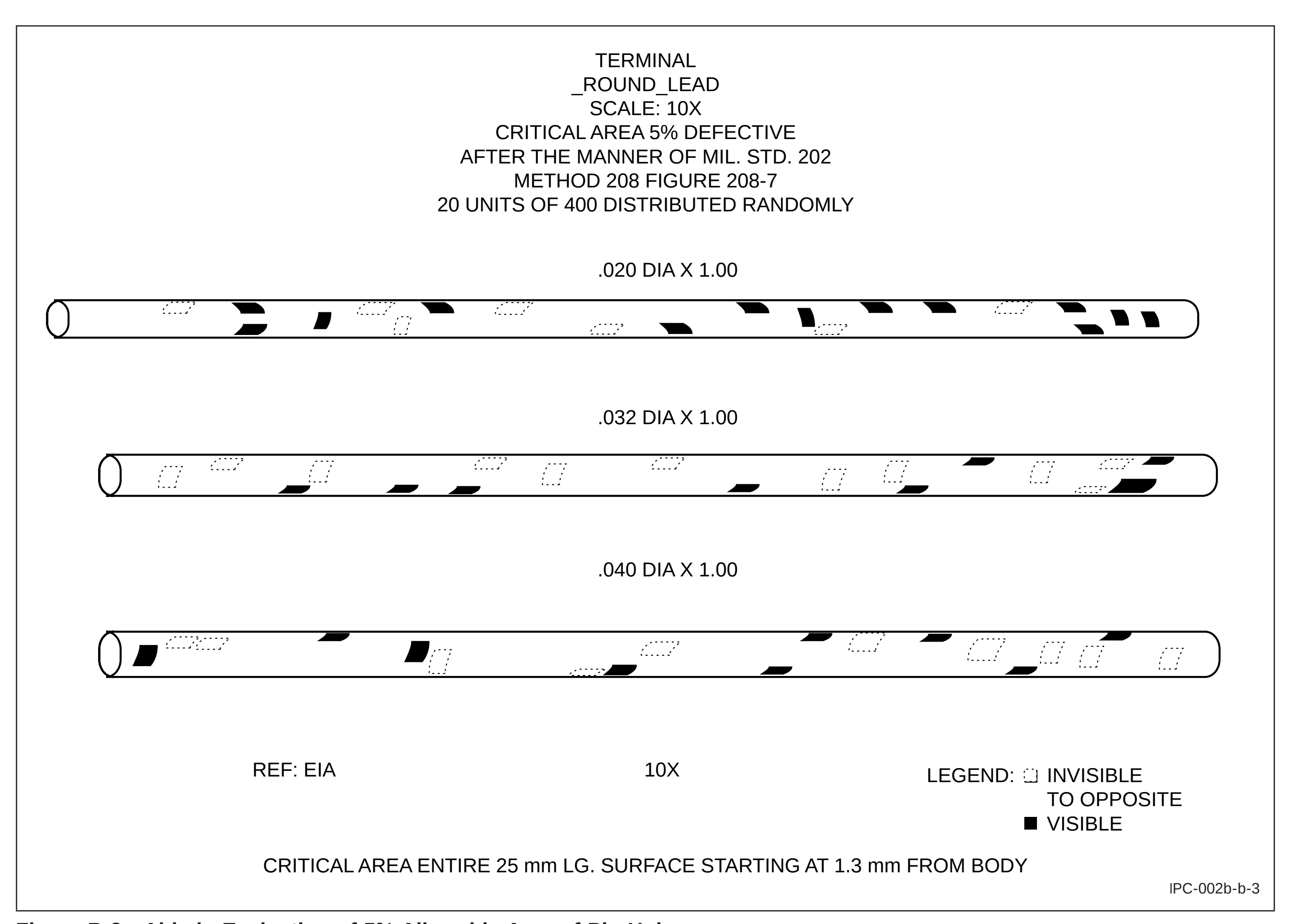


Figure B-3 Aids in Evaluation of 5% Allowable Area of Pin Holes

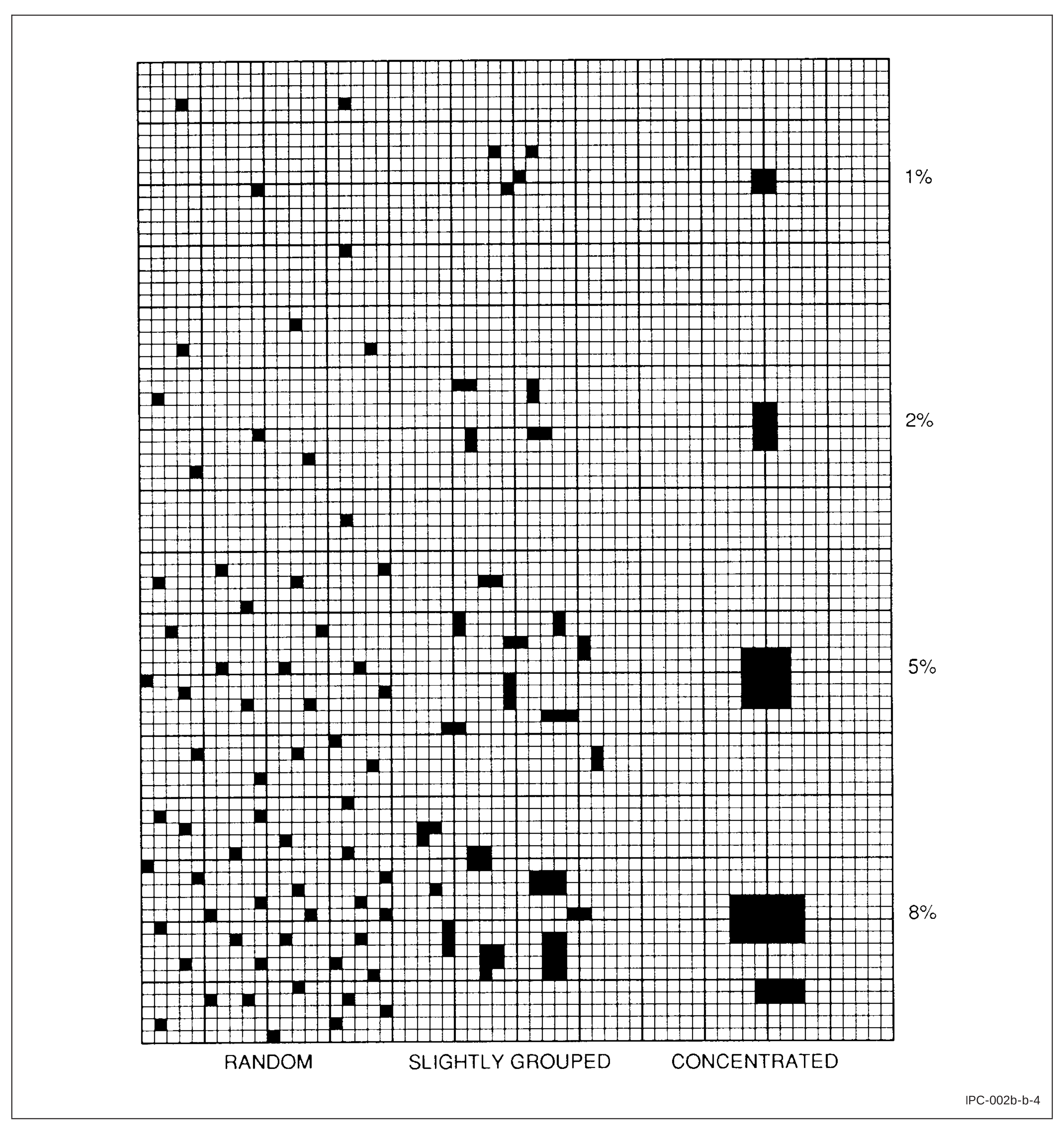


Figure B-4 Aid in Evaluation of 5% Allowable Area of Pin Holes

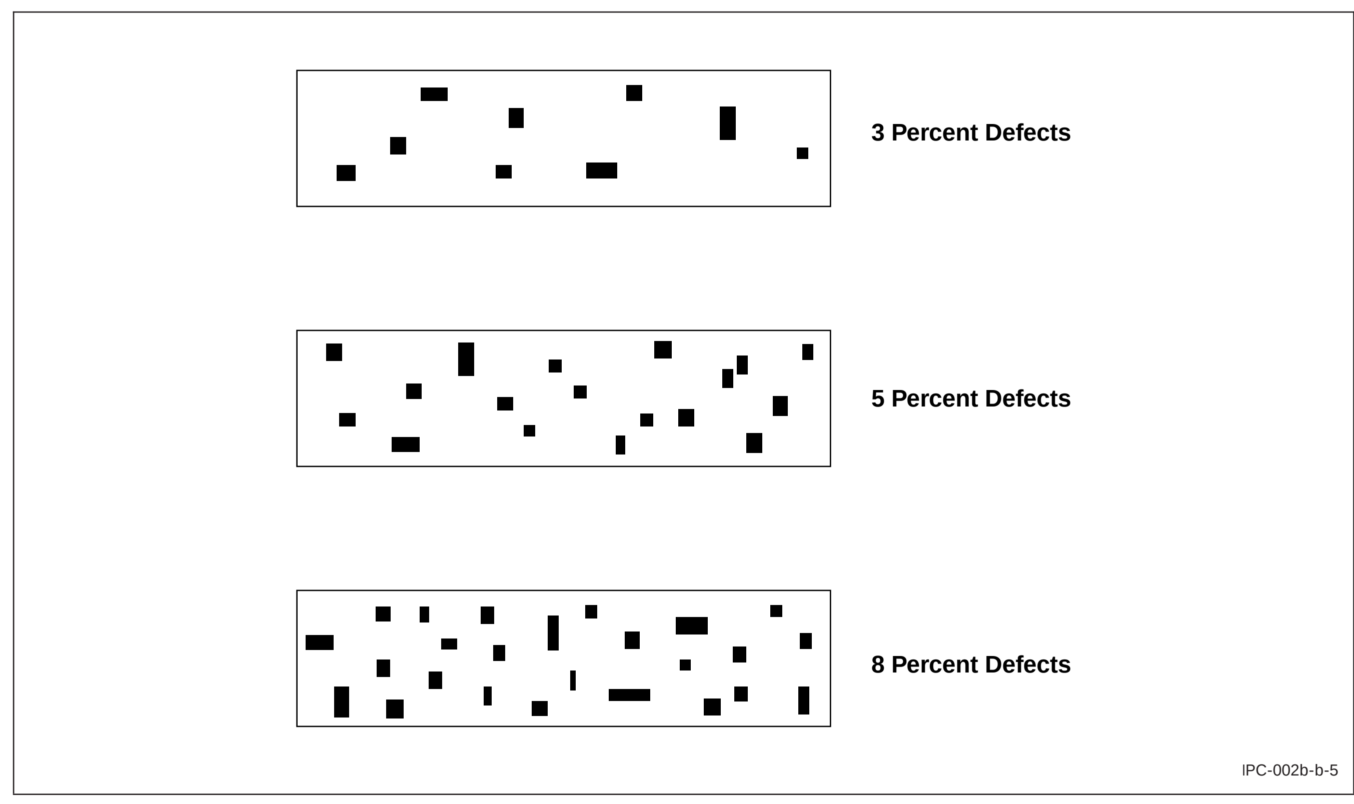


Figure B-5 Solderability Coverage Guide

Appendix C
Calculation of Maximum Theoretical Force

Maximum theoretical force is calculated using the procedure of Klein Wassink.[1]

The maximum force, in units of millinewtons (mN), is defined as:

Force (Max. Theoretical) = (t) (P) (cosine α) - (d)(g)(V)
= [0.4P - 0.08V] mN

where:

- P = The periphery of the specimen in millimeters, i.e., the length of the solder/lead/air interface as measured at maximum depth of immersion.
- V = The volume in cubic millimeters of the specimen that resides below the solder/lead/air interface as measured at the maximum depth of immersion.
- t = Surface tension of solder, 0.4 joules/m^2
- α = Wetting angle of solder to the lead under optimal conditions, i.e., $\alpha = 0^0$
- d = Density of solder, e.g., 8120 kg/m^3 for Sn60/Pb40 at 235°C or 8110 kg/m^3 for Sn60/Pb40 at 245°C
- g = Gravitational constant, 9.8 m/s^2

Periphery and volumes are to be calculated using the nominal values provided by the device supplier in the package drawing and the angles and depths of immersion as described in the specification above. The TOTAL periphery and volume, i.e., the sum of all leads being immersed, is to be used in this calculation.

Figure 1 below depicts a sample calculation for 132 I/O QFP.

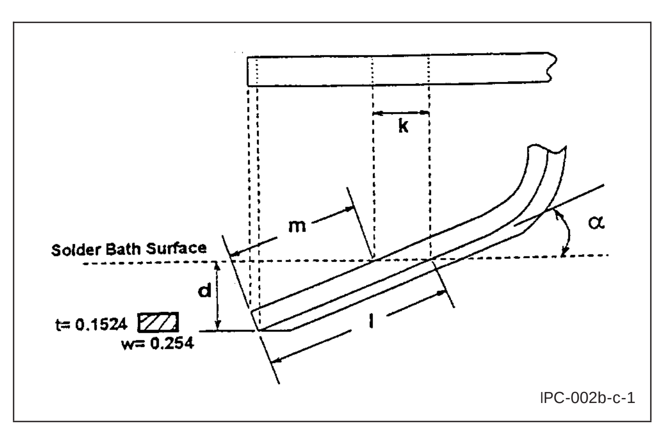


Figure C-1 Lead Periphery and Volume for a 132 I/O PQFP

Where:

Lead width (nominal) = w = 0.254 mm

Lead height (nominal) = t = 0.1524 mm

Immersion depth = d = 0.3 mm

Lead length immersed on bottom side at 20° angle and 0.3 mm depth = 1 = 0.877 mm

Lead length immersed on top side at 20° angle and 0.3 mm depth = m = 0.458 mm

Length of solder/lead/air interface along lead side = k = 0.446 mm

Total length per lead of solder periphery = 2k + 2w = 0.892 + 0.508 = 1.4 mm

P - Total length of periphery per side (33 leads) = 46.2 mm

Hence:

Total volume immersed per lead = 0.254 X 0.1524 X 0.458 + 0.5(0.1524 X 0.254 X 0.419) = 0.0177 + 0.0081 = 0.0258 mm^3

Therefore for 132 I/O QFP the maximum theoretical wetting force is

Maximum Force = (0.4 x 46.2) – (0.08 x 0.85)
= 18.41 mN

And, for a part of 46.2 mm total periphery:

Maximum Force per length of interface = 399 µN/mm

The force measured on a part in the Set A criteria must therefore be greater than 9.2 mN or 200 µN/mm.

Note: All forces are referenced to the corrected zero axis and not the zero force line except for the Appendix D calculation (parameter AA).

1. R. J. Klein Wassink, ''Soldering in Electronics,'' 2nd Edition, Electrochemical Publications, Ayr, Scotland, 1989, pp 308-309

Appendix D
Calculation of Integrated Value of Area of the Wetting Curve

The area is calculated using 50% of the maximum theoretical force (see Appendix C). Therefore, the area, AA, of the wetting curve for set A part is given in approximation as:

Area = {50% x 3.0 seconds x (Max. Theoretical Force mN) - (2.0 seconds x 0.08V)} mN s.

The value V is the volume of the part immersed in the solder bath as calculated in Appendix C. The maximum theoretical force is calculated as per Appendix A. The following assumptions are made:

1. The maximum buoyancy force holds for two (2) seconds contributing a negative area of the buoyancy force times two (2) seconds.
2. The part attains 50% of the maximum theoretical force at two (2) seconds and holds that value for the duration of the test, i.e.; three (3) seconds.

A sample calculation for a 132 I/O QFP is shown below.

V = Total Volume per side (33 leads) = 0.85 mm^3

Maximum Theoretical Force = 18.41 mN

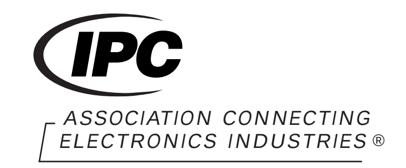
Therefore the area for a part in the Set A criteria is:

AA = (0.5 X 3.0 X 18.41) - (2.0 X 0.08 X 0.85)

= 27.62 - 0.136

= 27.48 mN seconds

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Standard Improvement Form

IPC/EIA/JEDEC J-STD-002B

The purpose of this form is to provide the Technical Committees of IPC and the EIA associations ECA and JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to IPC and JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to associations:

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1. I recommend changes to the following:

___ Requirement, paragraph number __________

___ Test Method number __________, paragraph number __________

The referenced paragraph number has proven to be:

___ Unclear ___ Too Rigid ___ In Error

___ Other ____

2. Recommendations for correction:

____

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3. Other suggestions for document improvement:

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2215 Sanders Road, Northbrook, IL 60062-6135
Tel. 847.509.9700 Fax 847.509.9798
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